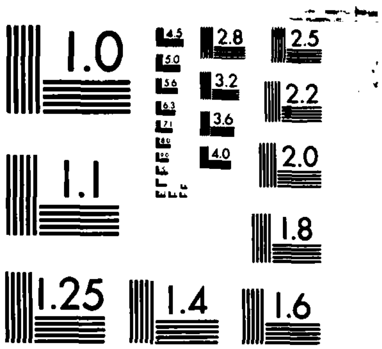
AD-A157 617   AN ANALYSIS OF ESTIMATING ERRORS ON GOVERNMENT CONTRACTS(U) ARMY MILITARY PERSONNEL CENTER ALEXANDRIA VA   D L DIEDRICH 22 MAR 85   1/2

UNCLASSIFIED   F/G 12/1   NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

②

AN ANALYSIS OF ESTIMATING ERRORS ON GOVERNMENT CONTRACTS

Captain David L. Diedrich
HQDA, MILPERCEN (DAPC-OPA-E)
200 Stovall Street
Alexandria, VA 22332

Final Report 22 March 85

Approved for public release; distribution unlimited.

A thesis submitted to The Ohio State University, Columbus, Ohio in partial fulfillment of the requirements for the Degree of Master of Science.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

AD-A157 617

4. TITLE (and Subtitle)

An Analysis of Estimating Errors on Government Contracts

5. TYPE OF REPORT & PERIOD COVERED

Final Report
22 March 85

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

Captain David L. Diedrich

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Student
HQDA, MILPERCEN (DAPC-OPA-E)
200 Stovall Street
Alexandria, Virginia 22332

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

HQDA
MILPERCEN, ATTN: DAPC-OPA-E
200 Stovall Street
Alexandria, Virginia 22332

12. REPORT DATE

22 March 85

13. NUMBER OF PAGES

107

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)

Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Thesis submitted in partial fulfillment for the Degree of Master of Science at the Ohio State University, Columbus, Ohio.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Estimating errors, regression analysis, U.S. Army Corps of Engineers Data, Cumulative distribution function

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This thesis considers what measures should be used to evaluate estimating errors of government estimates on competitively bid construction contracts. A data set from the U.S. Army Corps of Engineers was subjected to analysis using two measures of accuracy.

- over -

One objective of this research is to develop mathematical models and find cumulative distributions which may describe estimating practices within the Corps of Engineers. Other objectives are to offer large scale adjustments to compensate for any error present and to give a baseline for future studies and/or attempts to improve estimating accuracy.

It is found that there were significant estimating errors in the Corps of Engineer estimates. The variability of these errors is more than expected.

The principal conclusions are:

to retain as a measure of error, the standard percentage form, i.e.,

ERROR = ((OBSERVED - PREDICTED)/PREDICTED)*100; and

large scale adjustments are not useful.

Baselines were established for further research and study of estimating errors.

THESIS ABSTRACT

THE OHIO STATE UNIVERSITY
GRADUATE SCHOOL
(Please type.)

NAME: David L. Diedrich **QUARTER/YEAR:** Winter 1985

DEPARTMENT: Civil Engineering **DEGREE:** Master of Science

TITLE OF THESIS: An Analysis of Estimating Errors on Government Contracts

Summarize in the space below the purpose and principal conclusions of your thesis.

This thesis considers what measures should be used to evaluate estimating errors of government estimates on competitively bid construction contracts. A data set from the U.S. Army Corps of Engineers was subjected to analysis using two measures of accuracy.

One objective of this research is to develop mathematical models and find cumulative distributions which may describe estimating practices within the Corps of Engineers. Other objectives are to offer large scale adjustments to compensate for any error present and to give a baseline for future studies and/or attempts to improve estimating accuracy.

It is found that there were significant estimating errors in the Corps of Engineer estimates. The variability of these errors is more than expected.

The principal conclusions are:
to retain as a measure of error, the standard percentage form, i.e.,

ERROR = ((OBSERVED - PREDICTED)/PREDICTED)*100; and

large scale adjustments are not useful.
Baselines were established for further research and study of estimating errors.

Adviser's Signature

AN ANALYSIS OF ESTIMATING ERRORS

ON GOVERNMENT CONTRACTS

A Thesis

Presented in Partial Fulfillment of the Requirements for

the Degree Master of Science

By

David L. Diedrich, BS

The Ohio State University
1985

Approved By

Adviser
Department of Civil Engineering

ACKNOWLEDGEMENTS

For the support and guidance provided on this thesis and throughout the period of graduate study, the writer thanks Dr. Richard E. Larew. Thanks are also expressed to Dr. Fabian Hadipriono and Dr. Paul Thompson. I would like to thank my wife, Lin, for her loving support and my children, Scott, John, and Mike, for being there when I needed them and understanding when I was not there when they needed me.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS ii
LIST OF TABLES v
LIST OF FIGURES vi

CHAPTER . . . . Page

I. INTRODUCTION 1

General Background 1
Research Objectives 2
Significance of this Study 2
Limitation of this Study 3
Organization of Thesis 3

II. RESEARCH APPROACH 5

Introduction 5
Data Base 5
Descriptive Statistics of the Data 9
Analysis to be Performed on Accepted Data . . 10
Transition 14

III. PRESENTATION OF RESULTS 15

Introduction 15
Results of Error Modeling Using all of the Data 15
Results of Divisional Modeling 25
Pooled Results of Regional Models 33
Transition 45

IV. SUMMARY AND CONCLUSIONS 50

Summary of Analysis 50
Major Conclusions with Regards to Research Objectives 50
Quantitative Description of Current Estimating Practice 51
Large Scale Adjustments to Compensate for Error 52
Baseline for Future Study 53
Major Recommendations for Future Research . . 54

BIBLIOGRAPHY 55

TABLE OF CONTENTS
(Continued)

APPENDIX		Page
A.	LIST OF ORIGINAL DATA	57
B.	SINUSOIDAL FUNCTION	75
C.	PROGRESSIVE MODEL BUILDING	82
D.	CUMULATIVE DENSITY FUNCTION	83
E.	CDF OF DIVISIONAL MODELS FOR DELTA AND DELTA1	86
F.	CDF OF POOLED RESIDUALS AND OVERALL MODEL	105

LIST OF TABLES

TABLE		Page
2.1.	Data Summary	9
2.2.	Divisional Data Summary	10
3.1.	Descriptive Statistics	15
3.2.	Post Modeling Statistics	22
3.3.	Final Model for DELTA	23
3.4.	Final Model for DELTA1	24
3.5.	DELTA and Rescaled DELTA1 Compared	26
3.6.	DELTA Summary by Division	30
3.7.	DELTA1 Summary by Division	31
3.8.	Final Model for DELTA	34
3.9.	Final Model for DELTA1	38
3.10.	Post Modeling Summary for DELTA	42
3.11.	Post Modeling Summary for DELTA1	43
3.12.	DELTA and Rescaled DELTA1 Compared for Each Division	44
3.13.	Pooled VS Single Model Results for DELTA	46
3.14.	Pooled VS Single Model Results for DELTA1	47
A.1.	Original Data	57

LIST OF FIGURES

FIGURE		Page
2.1.	Bid Experience Report	6
3.1.	CDF of DELTA Before Modeling	17
3.2.	CDF of DELTA1 Before Modeling	18
3.3.	Residuals VS DATE1	20
3.4.	CDF of DELTA Before and After Modeling	27
3.5.	CDF of DELTA1 Before and After Modeling	28
3.6.	CDF of DELTA Overlaid	48
3.7.	CDF of DELTA Overlaid	49
B.1.	General Sinusoidal Function	75
B.2.	Y=SIN(X)	78
B.3.	Y=SIN(X+D)	78
B.4.	Y=SIN(X-D)	79
B.5.	Y=SIN(2*X)	79
B.6.	Y=SIN(.5*X)	80
B.7.	Y=2*SIN(X)	80
B.8.	Y=.5*SIN(X)	81
D.1.	Rank Ordered Delta VS Prob	84
D.2.	Fitted Curve Overlay on Rank Ordered Delta	85
E.1.	DELTA Before and After Modeling--EUR	87
E.2.	DELTA Before and After Modeling--MRD	88
E.3.	DELTA Before and After Modeling--NAD	89
E.4.	DELTA Before and After Modeling--NPD	90
E.5.	DELTA Before and After Modeling--OHR	91

LIST OF FIGURES
(Continued)

FIGURE (Continued)		Page
E.6.	DELTA Before and After Modeling--POD	92
E.7.	DELTA Before and After Modeling--SAD	93
E.8.	DELTA Before and After Modeling--SPD	94
E.9.	DELTA Before and After Modeling--SWD	95
E.10.	DELTA1 Before and After Modeling--EUR	96
E.11.	DELTA1 Before and After Modeling--MRD	97
E.12.	DELTA1 Before and After Modeling--NAD	98
E.13.	DELTA1 Before and After Modeling--NPD	99
E.14.	DELTA1 Before and After Modeling--OHR	100
E.15.	DELTA1 Before and After Modeling--POD	101
E.16.	DELTA1 Before and After Modeling--SAD	102
E.17.	DELTA1 Before and After Modeling--SPD	103
E.18.	DELTA1 Before and After Modeling--SWD	104
F.1.	Pooled Residuals and Overall Model--DELTA . .	106
F.2.	Pooled Residuals and Overall Model--DELTA1 . .	107

CHAPTER I

INTRODUCTION

1.1 GENERAL BACKGROUND

The United States Army Corps of Engineers is responsible for the management of the construction program for the Department of the Army, for determining the most advantageous bid on each project and awarding the contract to that low responsible bidder. Most contracts for construction are awarded, where it is feasible and practical, on the basis of the competitive bid process.

The U.S. Army Corps of Engineers is also responsible for making an independent estimate of the cost of each project, using the same plans and specifications as the bidders. This estimate is open at the same time the rest of the bids are opened and becomes the basis for screening the rest of the bids.

At the Ohio State University, in the Civil Engineering Department's Construction Engineering and Management Program, there has been recent research conducted by graduate students on the analysis of government estimates and the low bids received on public construction projects. Veselenak (12) performed analysis on data from the Naval

CHAPTER III

PRESENTATION OF RESULTS

3.1 INTRODUCTION

This chapter will present the results of each investigation performed. Some background information on the method will also be provided. The observed findings or apparent trends will be discussed.

3.2 RESULTS OF ERROR MODELING USING ALL OF THE DATA

Descriptive statistics for the initial examination of the two measures of estimating error, DELTA and DELTA1, are given in Table 3.1.

TABLE 3.1

Descriptive Statistics

VAR	MEAN	STD.DEV	MIN	MAX	SKEWNESS	KURTOSIS
DELTA	-14.6%	19.4%	-82.9%	133.3%	.30	8.28
DELTA1	- 9.1%	12.1%	-70.8%	40.0%	-1.30	7.20

Plots of the cumulative density function of DELTA and DELTA1 are shows in Figures 3.1 and 3.2. These plots and statistics show the current estimating error before modeling. The modeling procedure will attempt to account for this variability of the error present.

2.5 TRANSITION

Results of this study presented in Chapter 3 will be presented as *cumulative distribution functions* (cdfs) of the residuals. Appendix D gives more information on how these curves are constructed. SAS Graph procedures were used in making the cdf plots in this thesis. (9)

In the next chapter, results of grand modeling of the data will be presented, the results of Divisional modeling will be presented and discussed and finally the results of pooling the results of regional compared to grand modeling will be presented and discussed.

subjected to further analysis, entertaining non-linear models or seasonal effects models.

Appendix C covers this sequential model building process in more detail. This second model will be used and a second set of residual error terms will be generated. This second set of error terms will be subjected to further models as appropriate. Following these steps, one final overall model will be arrived at with final coefficients for our parameters and a final set of residuals (error terms). Descriptive statistics of the estimating error before and after modeling for both measures of error, DELTA and DELTA1 will be presented. An approximation of the data will be made using the Ramburg/Schmeiser(R/S) distribution. (3,44-49)

Following this modeling of the estimating error on all the data, the data will be partitioned by Engineer Division, and a separate analysis will be done for each Division. The same methodology will be applied to these data sets as was applied to the complete data set. Descriptive statistics will be presented on the error term, before and after modeling. The residuals from the regional modeling will be pooled and compared with the residual terms from the overall modeling to determine if modeling by Division significantly reduces the variability of estimating error.

Time was used by setting 1 January 1982 as zero time. Thus, a data value of 1.2 represents 14 March 1983.

Two measures of estimating error will be examined in this study:

DELTA = ((LOWBID-GOVEST)/GOVEST)*100 (1.1)

DELTA1 = ((LOWBID-GOVEST)/(LOWBID+GOVEST))*100 (1.2)

Equation 1.1 is the standard form for estimating error in percentage form, and is widely used in industry to measure error. Equation 1.2 was suggested (but not investigated) by Veselenak (12,47) as an alternative measure of estimating error that may be more responsive to the modeling effort. A negative value for either equation 1.1 or equation 1.2 will indicate that the government is overestimating the project cost.

Following the creation of the qualitative variables, the rescaling of DATE in terms of DATE1 and defining the response variables, a general linear model will be introduced to attempt to model the estimating error term with the variables in the data set. SAS Linear Stepwise Procedure will be used, at varying levels of significance to determine the best linear model. (8) A linear regression will then be performed on that model. The difference between the errors before and after modeling will be obtained. The residual error terms from this model

2.4 ANALYSIS TO BE PERFORMED ON ACCEPTED DATA

To meet the research objectives of this study, each data set will be quantitatively analyzed in terms of its estimating error. Once this error is quantitatively described, it will be presented in a manner that will enable grand adjustments to be recommended to compensate for this error. Regression will be used to give a baseline for evaluating future attempts to correct and improve the estimating practice of the Corps of Engineers or any one of it's Engineering Divisions.

In the data, there are three qualitative variables--DESCRIP, LOC, and NUMBID. The creation of N-1 levels of qualitative variables is required for the inclusion of these variables into the analysis. NUMBID is a qualitative variable to consider the distinction between negotiated and competitively bid projects. When NUMBID=0, a contract is negotiated, and a 1 level qualitative variable will be used to account for negotiated/bid project effects. An 8 level qualitative variable will be created to account for locational effects. DESCRIP will not be used in this analysis, as there are too many types of work in the data set to classify them into specific type of projects. Also, the full scope of the work cannot be determined from the information given. (It is noted that previous research by Veselenak (12) indicated that type of work did not significantly account for the estimating error.)

TABLE 2.2

Divisional Data Summary

	MEANS				NUMBER OF CASES			
	AMOUNTS IN MILLIONS OF DOLLARS			NUMBER OF				
DIV	PROGAMT	GOVEST	LOWBID	BIDDERS	FY82	FY83	FY84	TOTAL
EUR	2.22	1.35	1.14	10.20	175	107	25	307
MRD	3.02	2.34	2.06	7.86	13	21	18	52
NAD	2.39	2.09	1.57	10.10	69	35	14	118
NPD	2.28	1.60	1.25	9.67	9	22	3	34
OHR	2.02	1.48	1.23	7.76	21	9	9	39
POD	2.09	1.64	1.42	4.15	5	12	29	46
SAD	4.30	3.52	2.93	8.48	38	37	18	83
SPD	2.40	1.70	1.69	11.20	22	15	9	46
SWD	4.11	3.50	2.95	8.75	35	43	15	93

the data set. These projects are 20-40 times the magnitude of the mean project size and $10,000,000 over the next highest value-1/2 the range of the remaining values for project size. The elimination of these two projects on the basis as not representative of the true population reduces the usable data to 818 points.

2.3 DESCRIPTIVE STATISTICS OF THE DATA

Table 2.1 shows the overall range and mean for several variables in the data set. The earliest project recorded occurred on 17 November 1981 and the latest date was 25 June 1984. Table 2.2 shows the data by Division. The mean programmed amount, mean government estimate, mean low bid, and the mean number of bidders are given for each Division. The number of projects per fiscal year for each Division are also given.

TABLE 2.1

Data Summary

	MEAN VALUE	MINIMUM VALUE	MAXIMUM VALUE
PROGAMT	$2,727,892	$ 8,000	$31,000,000
GOVEST	$2,045,400	$19,000	$25,299,000
LOWBID	$1,707,529	$ 7,000	$17,117,000
NUMBID	9.8	0	49

4. NUMBID--The number of bidders that submitted bids for that project. A value of zero indicates that the project was negotiated work, rather than competitively bid upon.

5. PROGAMT--The program amount budgeted for that project, recorded in millions of dollars.

6. GOVEST--The government estimate of the cost of the project, in millions of dollars. This estimate is done internally by the Corps of Engineer Division responsible for the project, or by an architect-engineer design firm. It is prepared using the same detailed plans and specifications as the bidders have at their disposal. This independent estimate is opened and read at the bid opening.

7. LOWBID--The lowest responsible bid received for that project. This figure is recorded in millions of dollars.

In the original data set, there were 7 projects--(Appendix A, line numbers 6, 17, 19, 20, 21, 74, and 541) that did not have government estimates. These projects were eliminated as they had incomplete information. This reduced the usable data to 820 points. Two projects (Appendix A line numbers 161 and 481) are size outliers to

the continental United States, or the world. These Divisions are:

1. European Division (EUR);
2. Missouri River Division (MRD);
3. North Atlantic Division (NAD);
4. North Pacific Division (NPD);
5. Ohio River Division (OHR);
6. Pacific Ocean Division (POD);
7. South Atlantic Division (SAD);
8. South Pacific Division (SPD); and
9. South West Division (SWD).

The projects used in this study represent Military Construction Projects. These projects involve new construction, renovation or remodeling on Army installations located within the jurisdiction of the nine Engineering Divisions.

For each project there were seven variables:

1. LOC-----The Division that the installation was assigned to for project control purposes. For example, the Army installation of Fort Knox, Kentucky is assigned to the Ohio River Division (OHR) for project control purposes.
2. DATE----The date that the bids were opened for that project.
3. DESCRIP-A general description of the nature of the project.

PN	LOCATION	PROJECT DESCRIPTION	BIDS OPENED	NO OF BIDDERS	FULL SCOPE GOVT EST ($000)	LOW BID ($000)	PROG AMT ($000)	w/5 PERCENT CONTINGENCY O/E ($000)	DESCRIPTION SCOPE REDUCTION & AMT ($000)	MISCELLANEOUS REMARKS (A) = AWARDED
299E	Ft Riley	Barracks Mod	24Feb82	17	295	215	289	239		(A) 25 Mar 82
185E	Ft Irwin	Tracked Veh Maint Shades	2Mar82	20	297	277	349	307		(A) 10 Mar 82
155E	Ft Monmouth	Correct Fire Code	2Mar81	6	252	223	226	248		(A) 12 Mar 82
227E	Ft Polk	Observe Fire Tower	3Mar82	8	268	225	286	249		(A) 16 Mar 82
319	Ft Eustis	Ship to Shore Waste Coll	9Mar82	8	257	179	350	203		(A) 30 Mar 82
422E	Ft Bragg	Electronic Maint Shop	10Mar82	9	291	320	322	356		(A) 24 Mar 82
431	Ft Hood	Co Admin & Supply	18Mar82	10	410	349	430	368		(A) 15 Jun 82
101E	Anniston	Msl Elec & Hydr Maint	24Mar82	11	413	357	477	395		(A) 21 Apr 82
452E	Ft Belvoir	Install Ext Sup Postwide	24Mar82	5	178	144	207	161		(A) 6 Apr 82
301	Ft Campbell	Steam Plant Mod	8Apr82	6	177	122	300	137		(A) 21 May 82
153E	Ft Gordon	Tri-Tac Tng Fac	13Apr82	8	464	377	499	418		(A) 22 Apr 82
139E	Ft Greely	Renov Health Cl	13Apr82	6	446	405	443	455		(A) 22 Apr 82
2169E	Cp Roetz, GE	Mini Gyms	14Apr82	14	52	53	118	110		(A) 18 Jun 82
2170E	Haingruen, GE	Mini Gyms	14Apr82	14	66	45	118	106		(A) 18 Jun 82
2171E	Regen, GE	Mini Gyms	14Apr82	14	59	52	118	109		(A) 18 Jun 82
2172E	Weiden, GE	Mini Gyms	14Apr82	14	44	49	118	107		(A) 18 Jun 82
2173E	Schneeberg, GE	Mini Gyms	14Apr82	14	129	49	129	108		(A) 18 Jun 82

FIGURE 2.1: Recent Bid Experience Reports

CHAPTER II

RESEARCH APPROACH

2.1 INTRODUCTION

Regression analysis is the fitting of a probabilistic model to a data set to describe a response variable, in terms of a predictor variables. (5,62) Regression analysis to model construction data is widely used in the Construction Engineering and Management Program at the Ohio State University. This method will be the general approach used in the analysis of the data set from the U.S. Army Corps of Engineers.

2.2 DATA BASE

The data used in this study came from the Office of the Chief of Engineers, U.S. Army Corps of Engineers, Washington D.C.(11). Figure 2.1 is a copy of one sheet of this report. A list of the 827 contracts contained in this report is given in Appendix A. These 827 projects cover a two and one half fiscal year period, October, 1981 through June, 1984.

The Corps of Engineers has nine Engineering Divisions that are responsible for the management of construction for the Department of the Army. Each Division covers a part of

Chapter 2 discusses the data to be studied and the general research approach to the problem.

Chapter 3 presents the results of the analysis of the data set.

Chapter 4 contains a summary, major conclusions and recommendations on the evaluation of estimates within the U.S. Army Corps of Engineers.

and/or to be awarded. Underestimation of the cost of the project will complicate matters in the form of change orders, cost overruns and request for more funds. Any improvement in the accuracy of estimate prepared by the Corps of Engineers can have a great impact of the fiscal performance of the Corps of Engineers or any one of its Divisions.

1.4 LIMITATION OF THIS STUDY

It is beyond the scope of the thesis to attempt to tell the Corps of Engineers how to proceed to improve their estimates or change their estimating procedure. The data used in this study came from the U.S. Army Corps of Engineers Recent Bid Experience-Military Construction Activities Report. (11) It is assumed the government estimate and the lowbid contained in that report are the final figures on which the contract award was made.

1.5 ORGANIZATION OF THESIS

This thesis contains four chapters. A list of references follows the last chapter. Appendices comprise the last portion of the text.

Chapter 1 outlines the background of the Corps of Engineers functions, the study objectives and significance of the study.

Facilities Engineering Command (NAVFAC) and Selim (10) studied General Services Administration (GSA) data along with NAVFAC Data.

This thesis reports a study, done on data obtained from the U.S. Army Corps of Engineers, in which the government estimating accuracy was evaluated.

1.2 RESEARCH OBJECTIVES

This study focuses on three main objectives: The first objective is to quantitatively describe the current estimating practice within the U.S. Army Corps of Engineers Military Construction Program, to determine if improvement is needed in this area. The second objective is to offer a few simple adjustments that may be useful to help correct for any error that may exist within the estimating activity. The third objective is to give a baseline for future attempts to improve estimating accuracy by the Corps of Engineers, or any one of its Divisions.

1.3 SIGNIFICANCE OF THIS STUDY

A good accurate estimate of the cost of the project is a critical management tool. Overestimation on a project, saying it will cost more than it will, can cause an overcommitment of funds. This can prevent this fund from being available for other projects, either to be planned

The negative means for DELTA and DELTA1 indicate that the government is overestimating the cost of the project, on average. The range and variability of estimating error are much larger than expected by this author.

The Linear Stepwise Regression Procedure in SAS was used to initially explore the appropriateness of a linear model, for DELTA and DELTA1. Initially, the Stepwise Procedure was run, for both DELTA and DELTA1, with alpha=.15. This yielded the Models 3.1 and 3.2

$$DELTA = -12.39-(.002*GOVEST)-(.34*NUMBID)+(2.25*DATE1)-(6.22*NAD)-(5.46*OHR) \quad (3.1)$$

$$DELTA1 = -8.25-(.21*NUMBID)+(1.52*DATE1)-(4.05*NAD) \quad (3.2)$$

Next, the Stepwise Procedure was run using a smaller alpha level. It was decided to use alpha=.05, as this is a commonly accepted level for alpha. This yielded equations 3.3 and 3.4.

$$DELTA = -12.92-(3.66*NUMBID)+(2.30*DATE1)-(5.82*NAD) \quad (3.3)$$

$$DELTA1 = -8.25-(.21*NUMBID)+(1.52*DATE1)-(4.05*NAD) \quad (3.4)$$

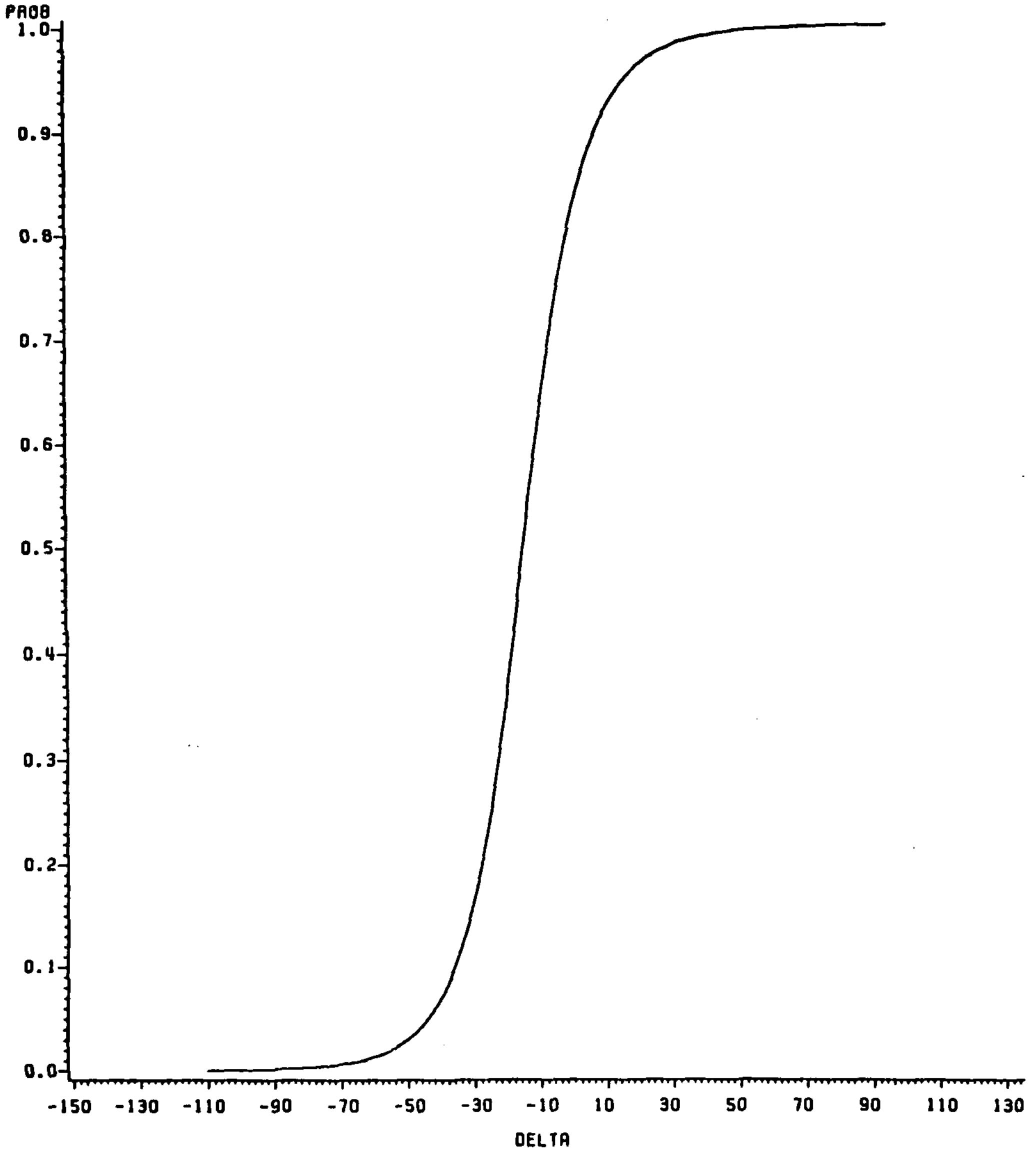


FIGURE 3.1: CDF Of DELTA Before Modeling

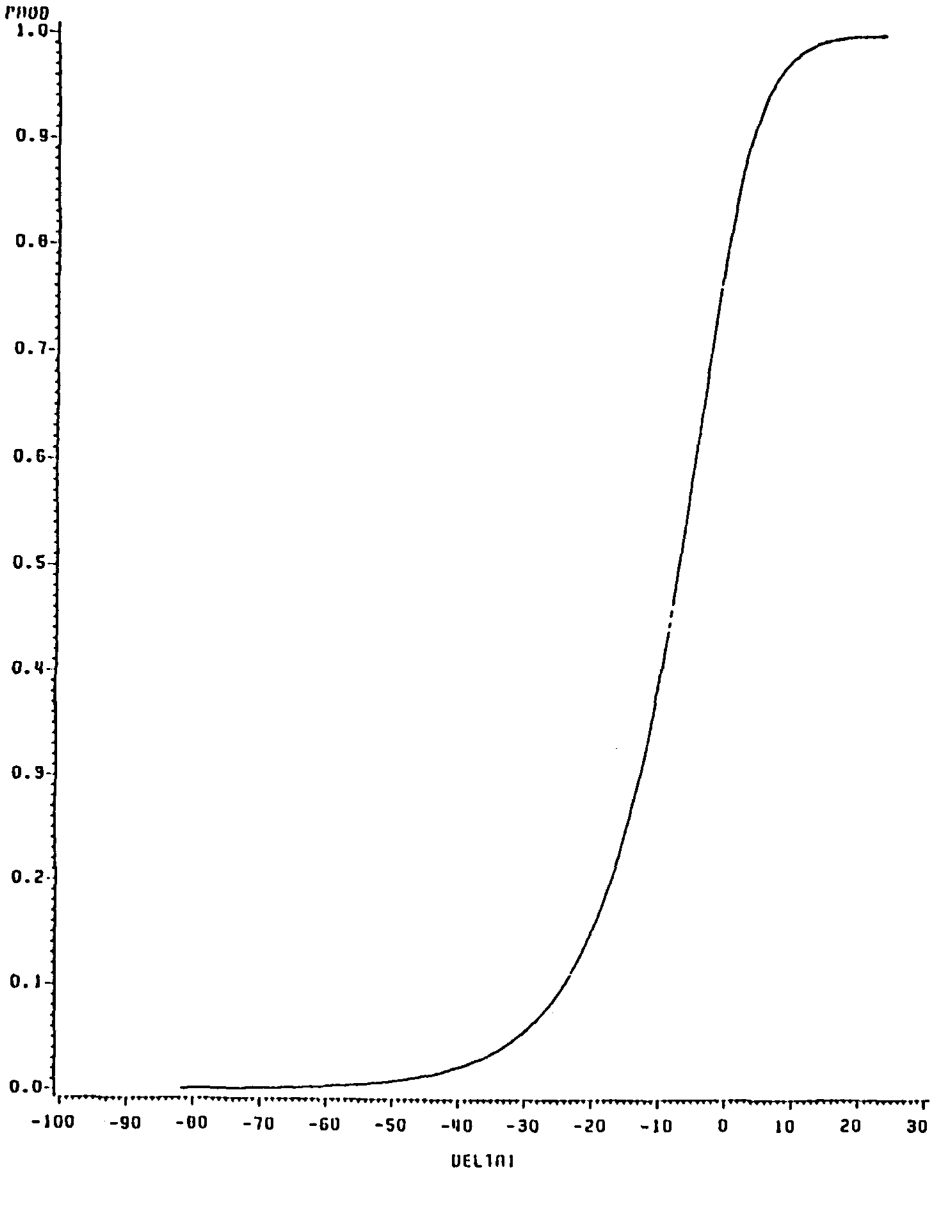


FIGURE 3.2: CDF of DELTA1 Before Modeling

These two equations had a value for the coefficient of determination[1] R^2 of .0449 and .0466 respectively. This model was useful in accounting for a very small proportion of the variance in the data. These two equations were used to find the first generation of residuals for further modeling. Once these residuals were created, they were plotted against all the variables in the model as well as those not in the model. Trends were noted and an appropriate model was decided upon to model this residual error. Figure 3.3 is a plot of the residual error term, RESID, versus DATE1.

The plot of RESID vs DATE1, showed promise of seasonal, or cyclical effects in the data, for both DELTA and DELTA1. This was not unexpected as the research done by Veselenak (12) and Selim (10) at the Ohio State University, also indicated presence of seasonal effects in similar data sets. One procedure to fit a seasonal model is to use a sinusoidal function to model the response variable. Appendix B gives the general approach taken for fitting the data with a sinusoidal function. Previous

---

1 R^2, the coefficient of determination, represents the proportion of the sum of squares of deviations of the response variable observations about their mean that can be attributed to a linear relation between the response and independent variables. R^2 is always between 0 and 1. A value of 1 indicates that the linear model accounts for all variability of the response variable. A value of 0 indicates that the model accounts for none of the variability (5, 83-84).

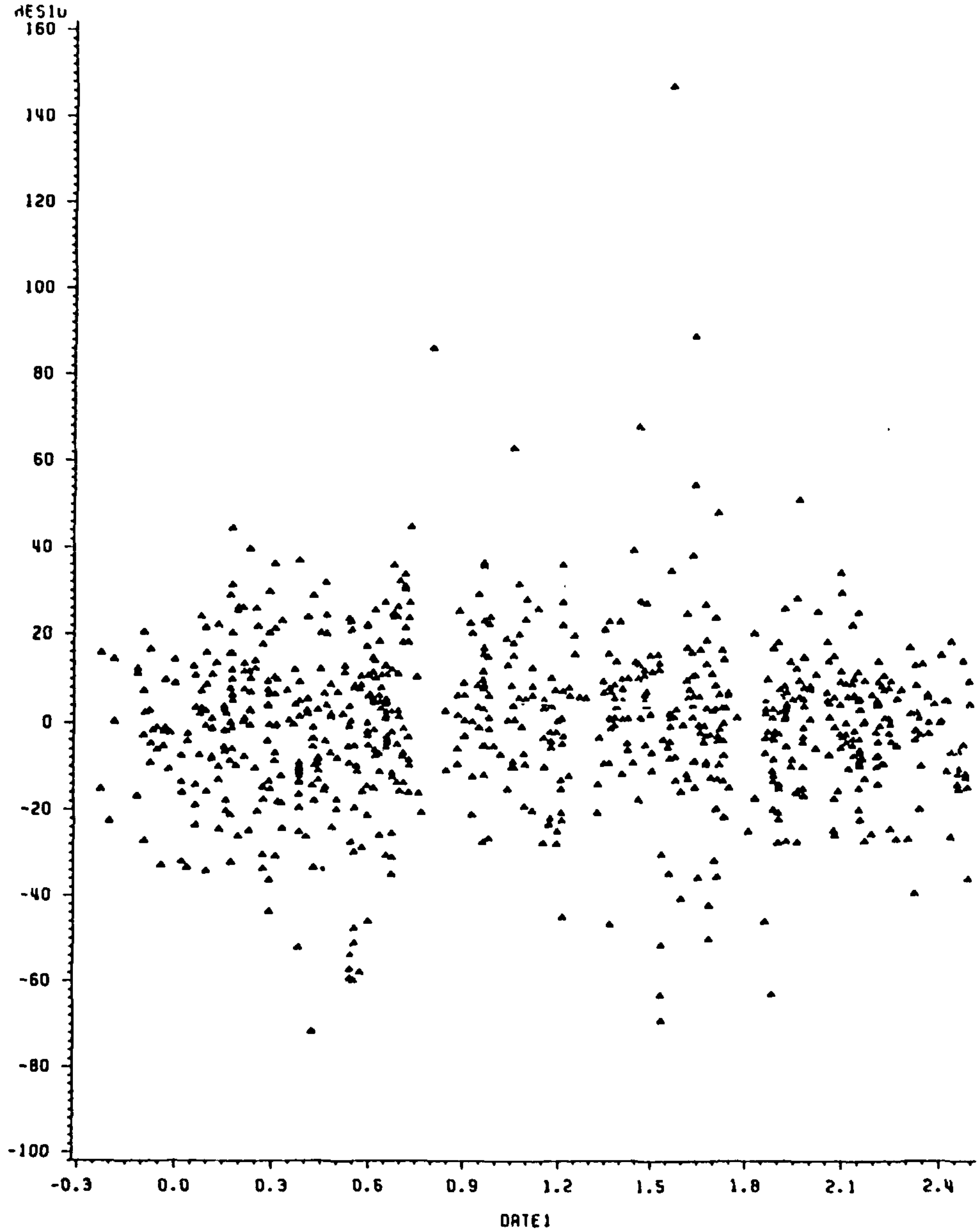


FIGURE 3.3: Residuals vs DATE1

research, as well as the plot of this data set, indicate that a cycle length of one year is an appropriate initial estimate. The general model:

$$RESID\ 1 = A(+B*SIN((C*DATE1)+D)) \qquad (3.5)$$

was used to initially fit the residual error terms. A range for each parameter was specified and input into PROC NLIN, the SAS Non-Linear Procedure. Equations 3.6 and 3.7 were found.

$$DELTA\ RESID1 = .11+(1.56*SIN((2\pi DATE1)+2.1813)) \qquad (3.6)$$

$$DELTA1\ RESID1 = .05+(1.25*SIN((2\pi DATE1)+1.7751)) \qquad (3.7)$$

The phase shift parameter, D, shifted the wave so that the low point in the wave, where the largest overestimation occurs to April 27 for DELTA and May 20 for DELTA1.

These values correspond to previous studies that indicate early spring as a time where construction jobs are scarce and hence there is more competition for each job, possibly indicating a cheaper price on each project.

The parameter estimates from the above model, indicate that there is evidence of seasonal effect in the data. The models account for 3% to 4% of the estimating error. This seasonal model may be confounded by the data, and Divisional modeling may allow this trend to show more clearly.

The residual errors from these models were plotted against all variables in the model and those not in the model to look for trends that may indicate alternative models that should be considered. Analysis of these plots showed no apparent trends in the data, and it was decided that the best model for both DELTA and DELTA1 is as given in equation 3.8:

$$DELTA = A+(B*NUMBID)+(C*DATE1)+(D*NAD)+(E*TIME) \quad (3.8)$$

where TIME=SIN*((2π*DATE1)+F), and F has the value of 2.1813 for DELTA and 1.7751 for DELTA1. Final regression run results are listed in Tables 3.3 and 3.4.

TABLE 3.2

Post Modeling Statistics

VARIABLE	MEAN	STD DEV	RANGE	SKEWNESS	KURTOSIS
DELTA	0	18.82	218.24	.44	9.44
DELTA1	0	11.78	112.39	-1.25	7.72

Although these models do not account for much of the variability of the data, they may be useful to future attempts in improving the estimating accuracy of the Corps of Engineers. Following modeling, the error could be characterized by the statistics in Table 3.2. The modeling

TABLE 3.3

Final Model for DELTA

MODEL	DEPARTMENT VARIABLE DELTA
	R^2 = .06
	F = 12.60
	P $\leq$ .9999

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-10.08	1.87	-5.36	.0001
NUMBID	- .63	.13	-4.95	.0001
DATE1	1.95	.90	-2.15	.0314
NAD	- 5.76	1.89	-3.04	.0024
TIME	1.59	.99	1.61	.1076

TABLE 3.4

Final Model for DELTA1

MODEL

DEPARTMENT VARIABLE DELTA

R^2 = .06

F = 13.61

P $\leq$ .9999

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-6.29	1.17	-5.35	.0001
NUMBID	- .39	.08	-4.92	.0001
DATE1	1.25	.56	2.22	.0270
NAD	-4.02	1.18	-3.41	.0007
TIME	1.29	.59	2.18	.0294

effort showed a slight decrease in standard deviation, but these models do not significantly reduce the ranges of estimating errors.

Overlays of the cumulative density functions before and after modeling are shown in Figures 3.4 and 3.5. Comparisons of the means and standard deviations of DELTA and DELTA1, indicate that DELTA is equivalent to a factor times DELTA1. Table 3.5 demonstrates this fact. Divisional models were next considered to improve upon what was achieved with modeling the entire data set.

3.3 RESULTS OF DIVISIONAL MODELING

Nine new data sets were created from our original set, one for each Division. The estimating error for each Division was modeled and described quantitatively. The loss of degrees of freedom in each data set, will hopefully be offset by the more accurate models, that will be derived for each Division. These models may be useful to each Division in setting a baseline for future attempts in improving their estimating accuracy.

Initial examination of the estimating error of each Division, as measured by DELTA and DELTA1, yielded the following information. The European Division (EUR) had the largest number of projects, 307, as well as the largest range of estimating error, 216%. The North Atlantic

TABLE 3.5

DELTA and Rescaled DELTA 1 Compared

	DELTA	RESCALED DELTA1	RESCALE FACTOR (F)	DELTA1
MEAN	-14.61	-14.58	1.6	-9.73
STD.DEV	19.39	19.39	1.6	12.12

$$\bar{F} = \sum_{i=1}^{2} \frac{F_i}{2} = 1.60$$

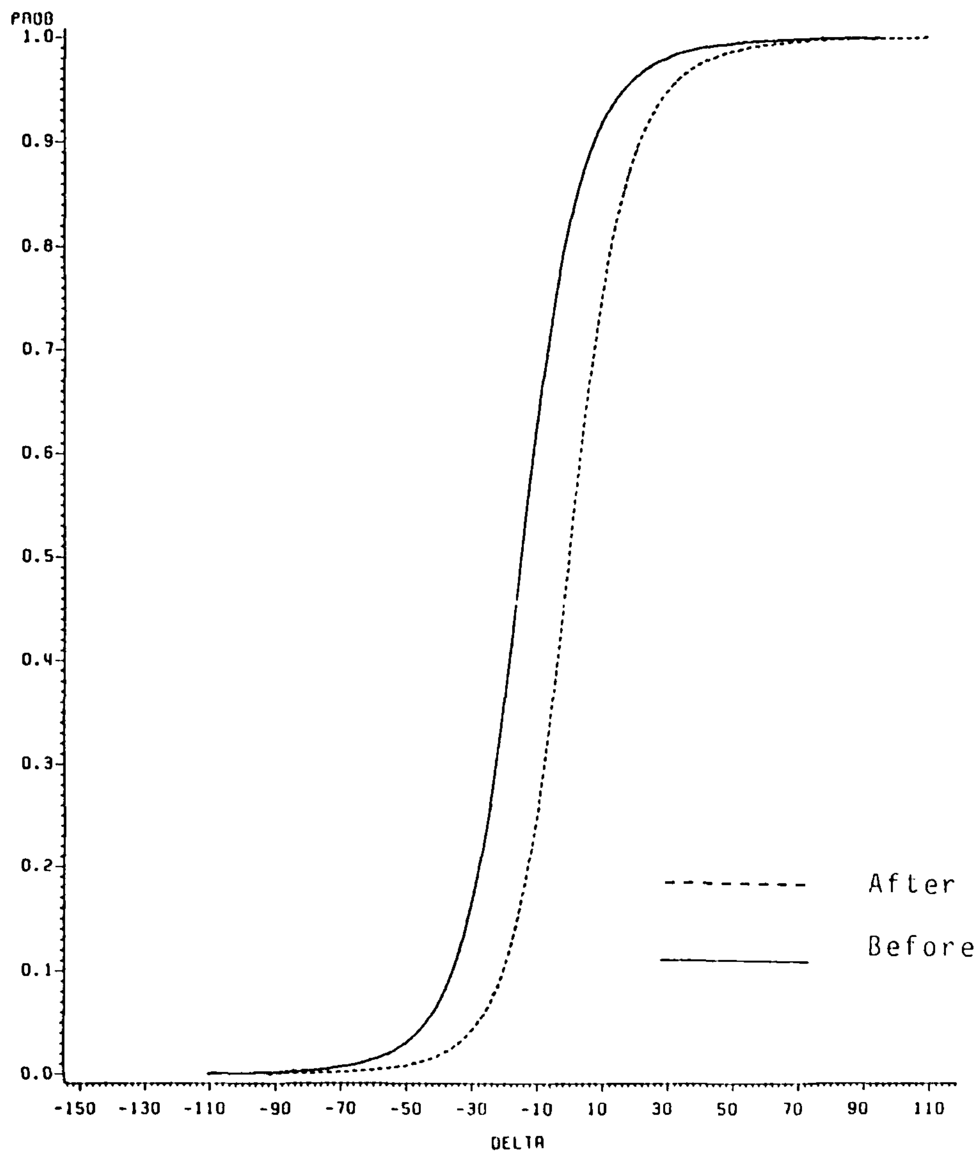


FIGURE 3.4: CDF of DELTA Before and After Modeling

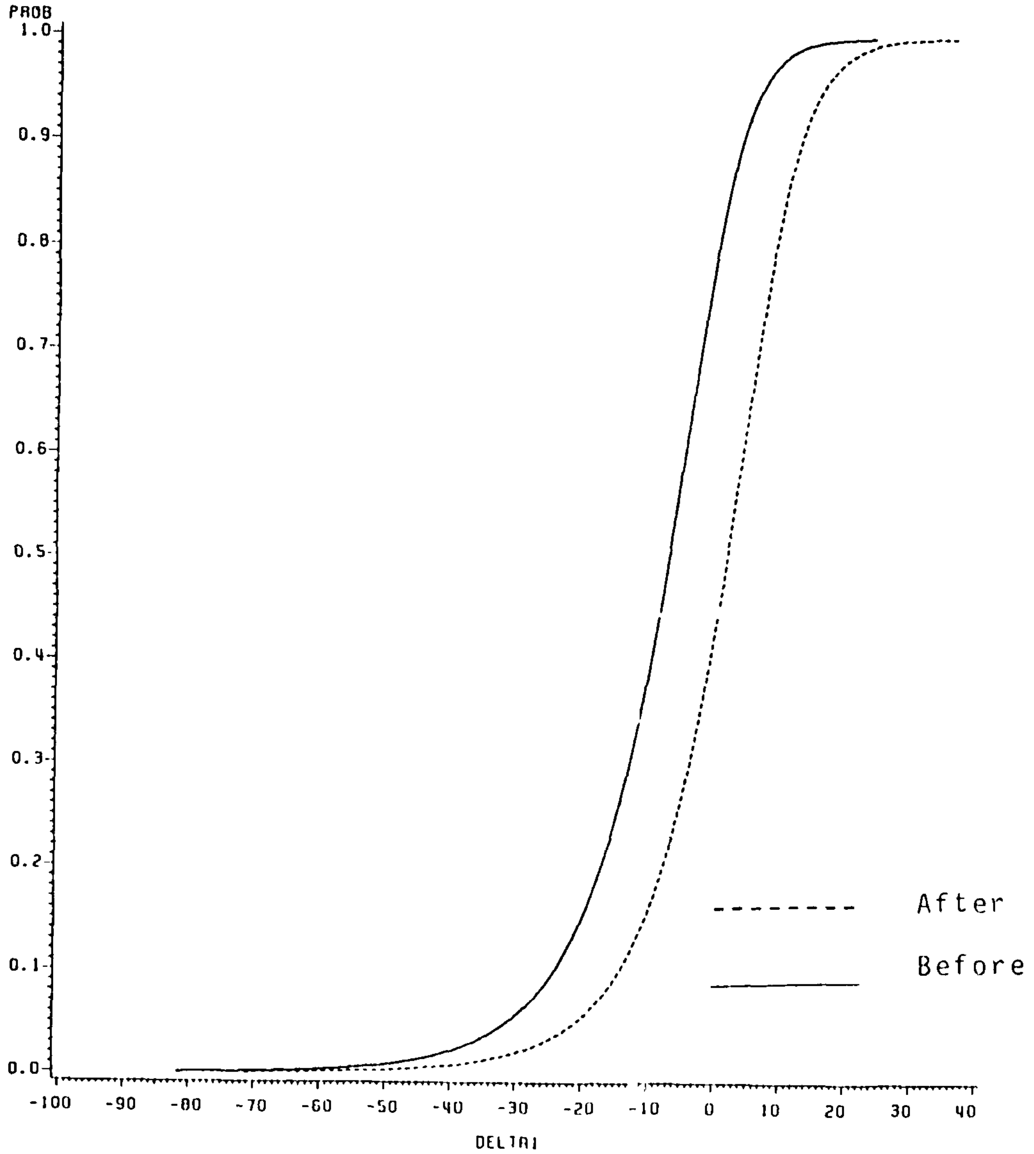


FIGURE 3.5: CDF of DELTA1 Before and After Modeling

Division [illegible] largest mean estimating error, -20.6%, [illegible] largest standard deviation, 22.5%. The North [illegible] (NAD) had the largest mean estimating [illegible] -1[illegible]% (using DELTA1). The European Division [illegible] had the largest range of error, 110.8%, as well as the largest standard deviation in the error of 14.2%. Tables 3.6 and 3.7 summarize the statistics of DELTA and DELTA1 for each Division.

Linear stepwise regression was applied to each data set, with the level of significance (alpha) equal to .05. The coefficient of determination (R^2) ranged from .019 to .652 for DELTA and DELTA1. The South Pacific Division (SPD) had no linear model that was significant at alpha=.05 for DELTA or DELTA1. The Missouri River Division (MRD) and the Pacific Ocean Division (POD) had no linear model for DELTA1 which was significant at alpha=.05.
As the results of the overall modeling of the Corps of Engineer data indicated that seasonality was a factor in the explanation of error, this was the next model applied to the first generation residuals from linear modeling. This procedure proceeded as the fitting of of the model did to all the combined data in Section 3.2 of this thesis.

For the modeling DELTA's residuals, some Divisions exhibited a stronger tendency than others toward seasonality. The low point of the sinusoidal function (the

TABLE 3.11

Post Modeling Summary for DELTA1

DIV	# CASES	MEAN(%)	STANDARD DEVIATION(%)	RANGE(%)	SKEWNESS	KURTOSIS
EUR	307	0	14.01	114.52	-1.46	7.66
MRD	52	0	7.28	41.22	.05	4.70
NAD	118	0	13.31	73.09	- .14	3.61
NPD	34	0	7.06	34.23	- .56	3.56
OHR	39	0	8.94	37.47	- .75	3.20
POD	46	0	5.53	27.45	.72	4.36
SAD	93	0	10.31	66.07	-1.65	8.26
SPD	46	0	9.00	38.68	- .31	2.72
SWD	83	0	6.77	38.38	- .55	4.01

TABLE 3.10

Post Modeling Summary for DELTA

DIV	# CASES	MEAN(%)	STANDARD DEVIATION(%)	RANGE(%)	SKEWNESS	KURTOSIS
EUR	307	0	21.96	219.06	.72	11.28
MRD	52	0	12.14	60.65	-.24	3.63
NAD	118	0	21.47	130.57	.82	5.32
NPD	34	0	9.25	44.04	.93	4.43
OHR	39	0	13.98	62.62	- .44	2.97
POD	46	0	13.02	72.86	. 05	4.58
SAD	93	0	15.95	86.13	- .81	4.14
SPD	46	0	15.26	68.32	- .09	2.78
SWD	83	0	11.51	62.31	- .02	3.28

TABLE 3.9

Final Model for DELTA1
(Continued)

MODEL SPD | **DEPARTMENT VARIABLE DELTA1**

R^2 = .11
F = 5.81
P ≤ .9799

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-10.01	1.48	-6.75	.0001
TIME	4.50	1.87	2.41	.0201

MODEL SWD | **DEPARTMENT VARIABLE DELTA1**

R^2 = .22
F = 11.76
P ≤ .9999

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-1.30	1.81	- .72	.4746
NUMBID	- .67	.19	-3.57	.0006
TIME	-2.61	1.01	-2.58	.0115

TABLE 3.9

Final Model for DELTA1
(Continued)

MODEL OHR — **DEPARTMENT VARIABLE DELTA1**

R^2 = .11
F = 2.48
P ≤ .9023

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-5.81	2.89	-2.01	.0519
NUMBID	- .70	.32	-2.19	.0348

MODEL POD — **DEPARTMENT VARIABLE DELTA1**

R^2 = .03
F = 1.60
P ≤ .7871

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-4.96	1.55	-3.20	.0025
TIME	-2.57	2.03	1.26	.2128

MODEL SAD — **DEPARTMENT VARIABLE DELTA1**

R^2 = .12
F = 12.74
P ≤ .9994

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-1.80	2.09	- .86	.3910
NUMBID	- .74	.21	-3.57	.0006

TABLE 3.9

Final Model for DELTA1
(Continued)

MODEL NAD — **DEPARTMENT VARIABLE DELTA1**

R^2 = .10
F = 13.92
P $\leq$ .9997

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-4.551	2.62	-1.74	.0855
NUMBID	- .851	.23	3.73	.0003

MODEL NPD — **DEPARTMENT VARIABLE DELTA1**

R^2 = .68
F = 12.28
P $\leq$ .9999

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-2.76	3.06	- .90	.3752
NUMBID	- .76	.20	-3.71	.0009
PROGAMT	-3.40	1.32	2.58	.0155
GOVEST	-7.99	2.02	-3.15	.0005
DATE1	5.88	1.66	3.53	.0014
TIME	-2.98	1.90	-1.57	.1286

TABLE 3.9

Final Model for DELTA1

MODEL EUR — **DEPARTMENT VARIABLE DELTA1**

R^2 = .02
F = 3.18
P $\leq$ .9573

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	- 6.13	1.75	-3.51	.0005
NUMBID	- .26	.15	-1.79	.0749
TIME	- 2.44	1.13	-2.15	.0321

MODEL MRD — **DEPARTMENT VARIABLE DELTA1**

R^2 = .08
F = 4.42
P $\leq$ .9595

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-5.73	1.09	-5.25	.0001
NUMBID	3.05	1.45	2.10	.0405

TABLE 3.8

Final Model for DELTA
(Continued)

MODEL SWD

DEPARTMENT VARIABLE DELTA

R^2 = .22
F = 11.65
P ≤ .9999

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	- 2.27	3.09	- .73	.4645
NUMBID	- 1.16	.32	-3.62	.0005
TIME	4.26	1.72	2.48	.0154

TABLE 3.8

Final Model for DELTA
(Continued)

MODEL POD

DEPARTMENT VARIABLE DELTA

R^2 = .09
F = 4.41
P ≤ .9584

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-14.01	2.42	-5.78	.0001
NUMBID	- .72	.34	2.10	.0416

MODEL SAD

DEPARTMENT VARIABLE DELTA

R^2 = .13
F = 14.90
P .9998

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	- 2.81	3.20	- .88	.3820
NUMBID	- 1.24	.32	-3.86	.0002

MODEL SPD

DEPARTMENT VARIABLE DELTA

R^2 = .11
F = 5.60
P .9775

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-16.78	2.51	-6.68	.0001
NUMBID	7.49	3.17	2.36	.0225

TABLE 3.8

Final Model for DELTA
(Continued)

MODEL NPD

DEPARTMENT VARIABLE DELTA

R^2 = .69
F = 12.42
P $\leq$ .9999

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	- 6.85	5.12	-1.34	.1916
NUMBID	- .30	.33	-3.93	.0005
PROGAMT	5.70	2.18	2.61	.0143
GOVEST	-13.45	3.36	-4.00	.0004
DATE1	11.34	2.88	3.93	.0005
TIME	5.41	2.97	1.82	.0788

MODEL OHR

DEPARTMENT VARIABLE DELTA

R^2 = .12
F = 5.30
P $\leq$ .9730

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-10.06	4.51	-2.23	.0317
NUMBID	- 1.15	.50	-2.30	.0270

TABLE 3.8

Final Model for DELTA

MODEL EUR

DEPARTMENT VARIABLE DELTA

R^2 = .04
F = 6.34
P ≤ .9998

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-7.47	2.70	-2.76	.0061
NUMBID	- .59	.23	-2.57	.0104
TIME	5.44	1.85	2.94	.0354

MODEL MRD

DEPARTMENT VARIABLE DELTA

R^2 = .12
F = 3.34
P ≤ .9562

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-4.25	4.32	- .98	.3296
NUMBID	- .75	.05	-1.41	.1651
TIME	4.11	2.84	1.45	.1549

MODEL NAD

DEPARTMENT VARIABLE DELTA

R^2 = .08
F = 10.78
P ≤ .9986

INDEPENDENT VAR	PARAMETER ESTIMATE	STANDARD ERROR	t	P
INTERCEP	-8.31	4.23	-1.96	.0519
NUMBID	-1.21	.37	-3.28	.0014

rescaled values for the mean and standard deviation are shown in Table 3.12. From this table it is observed that there is no significant difference in the mean and standard deviation of these two measures of error.

3.4 POOLED RESULTS OF REGIONAL MODELS

Once the final models for each Division were determined, the residual errors from these models were pooled. These pooled results were compared with the results from the single models. These statistics are summarized and presented in Table 3.13 and 3.14.

There is a slight reduction in variability of the error, standard deviation, for both DELTA and DELTA1, with the Divisional model. The mean of the estimating error is the same for both models. The plots of the cumulative density function of the pooled results and the overall model for both DELTA and DELTA1 are presented in Appendix F. The reduction of variability for both DELTA and DELTA1 is so slight that it is almost non-existent. The difference in reduction in variability for DELTA compared to DELTA1 is likewise insignificant.

Figures 3.6 and 3.7 show the cdf curves of DELTA before modeling for all Divisions overlaid on one another. These plots indicate that approximately 85% to 90% of the bids received are less than 10% over the government

point of maximum government overestimation) varies from Division. No real pattern can be determined. For DELTA1's residuals, the same was found to exist.

The residual error terms from this seasonal modeling were examined and plotted against all variables in the model and those not yet included in the model. No further trends could be deduced from these plots and "best" models were decided on for the final models for each Division. These final models are presented in Tables 3.8 and 3.9.

Following the acceptance of the final models, final regressions were run on these models. Final estimates of the parameters were found, and descriptive statistics were calculated. These statistics are summarized and presented in Tables 3.10 and 3.11. In most cases, 13 of 18, the range of the estimating error reduced after modeling. There appears to be no significant difference between DELTA1 and DELTA models.

Appendix E contains plots of the cumulative density functions of the before and after modeling errors for each Division. For each Division there are two plots, one for DELTA and one for DELTA1. On each plot there are two functions, before modeling error and after modeling error. To compare the mean and standard deviation of DELTA and DELTA1 there is a need to rescale one or the other. This author choose to rescale DELTA1 (equation 1.2). The

TABLE 3.7

DELTA1 Summary by Division

DIV #	CASES	MEAN(%)	STD. DEV(%)	RANGE(%)	SKEWNESS	KURTOSIS
EUR	307	- 9.11	14.15	110.84	-1.51	7.57
MRD	52	- 6.69	7.37	32.11	- .27	2.99
NAD	118	-13.19	14.10	80.64	- .39	3.42
NPD	34	- 8.41	9.89	35.29	- .42	2.31
OHR	39	-11.28	9.54	41.05	- .62	2.75
POD	46	- 6.35	7.41	40.31	.32	4.69
SAD	93	- 8.17	11.11	69.16	- .61	7.89
SPD	46	- 8.49	9.57	40.71	- .37	2.87
SWD	83	- 7.05	7.69	46.33	- .71	4.75

TABLE 3.6

DELTA Summary by Division

DIV	# CASES	MEAN(%)	STD DEV(%)	RANGE(%)	SKEWNESS	KURTOSIS
EUR	307	-13.92	22.41	216.10	.54	10.04
MRD	52	-11.67	12.94	56.80	.09	2.87
NAD	118	-20.58	22.48	136.71	.54	4.42
NPD	34	-14.05	16.58	60.18	- .10	2.29
OHR	39	-19.03	14.96	66.23	- .27	2.65
POD	46	-11.02	13.79	75.06	1.04	5.73
SAD	93	-13.39	17.22	92.17	- .74	3.82
SPD	46	-14.26	16.20	70.61	.10	3.05
SWD	83	-12.24	13.13	76.77	- .10	3.77

TABLE 3.12

DELTA and Rescaled DELTA1 Compared for Each Division

MEAN

	DELTA	RESCALED DELTA1	DELTA1	RESCALE FACTOR (F)
EUR	-13.92	-15.13	- 9.12	1.53
MRD	-11.67	-11.11	- 6.69	1.74
NAD	-20.58	-21.70	-13.19	1.56
NPD	-14.05	-13.96	- 8.41	1.67
OHR	-19.03	-18.72	-11.28	1.63
POD	-11.02	-10.55	- 6.36	1.73
SAD	-13.39	-13.57	- 8.17	1.63
SPD	-14.26	-14.08	- 8.49	1.68
SWD	-12.24	-11.70	- 7.05	1.73

$$\bar{F} = \frac{\sum_{i=1}^{9} F_i}{9} = 1.66$$

STANDARD DEVIATION

	DELTA	RESCALED DELTA1	DELTA1	RESCALE FACTOR (F)
EUR	22.41	23.50	14.15	1.58
MRD	12.94	12.23	7.37	1.75
NAD	22.48	23.40	14.10	1.59
NPD	16.58	16.42	9.89	1.67
OHR	14.96	15.84	9.54	1.56
POD	13.79	12.30	7.41	1.86
SAD	17.22	18.45	11.11	1.55
SPD	16.20	15.90	9.57	1.61
SWD	13.13	12.78	7.69	1.71

$$\bar{F} = \frac{\sum_{i=1}^{9} F_i}{9} = 1.66$$

estimate. If the government were to reject bids that are 10% or more above their estimate, this would mean that they would reject approximately 10% to 15% of the bids. This is an area that Larew's theory of socially acceptable biasing could apply (4). With the type of analysis performed, it would be possible for the Corps of Engineers or any of its Divisions to formulate their objectives, in terms of a socially acceptable percentage of bids to be rejected (for being too high). This could be done by the use of a factor applied to the government estimate, without a change in estimating procedure.

3.5 TRANSITION

In the next chapter the results will be summarized and conclusions drawn on those results. Recommendations will be presented for consideration for future research.

TABLE 3.13

Pooled VS Single Model Results for DELTA

MODEL	MEAN(%)	STD(%)	RANGE(%)	SKEWNESS	KURTOSIS
Single	0	18.78	218.24	.44	9.43
Pooled	0	18.23	219.06	.58	10.75

TABLE 3.14

Pooled VS Single Model Results for DELTA1

MODEL	MEAN(%)	STD(%)	RANGE(%)	SKEWNESS	KURTOSIS
Single	0	11.73	112.39	- 1.2	7.72
Pooled	0	11.44	114.52	-1.20	8.12

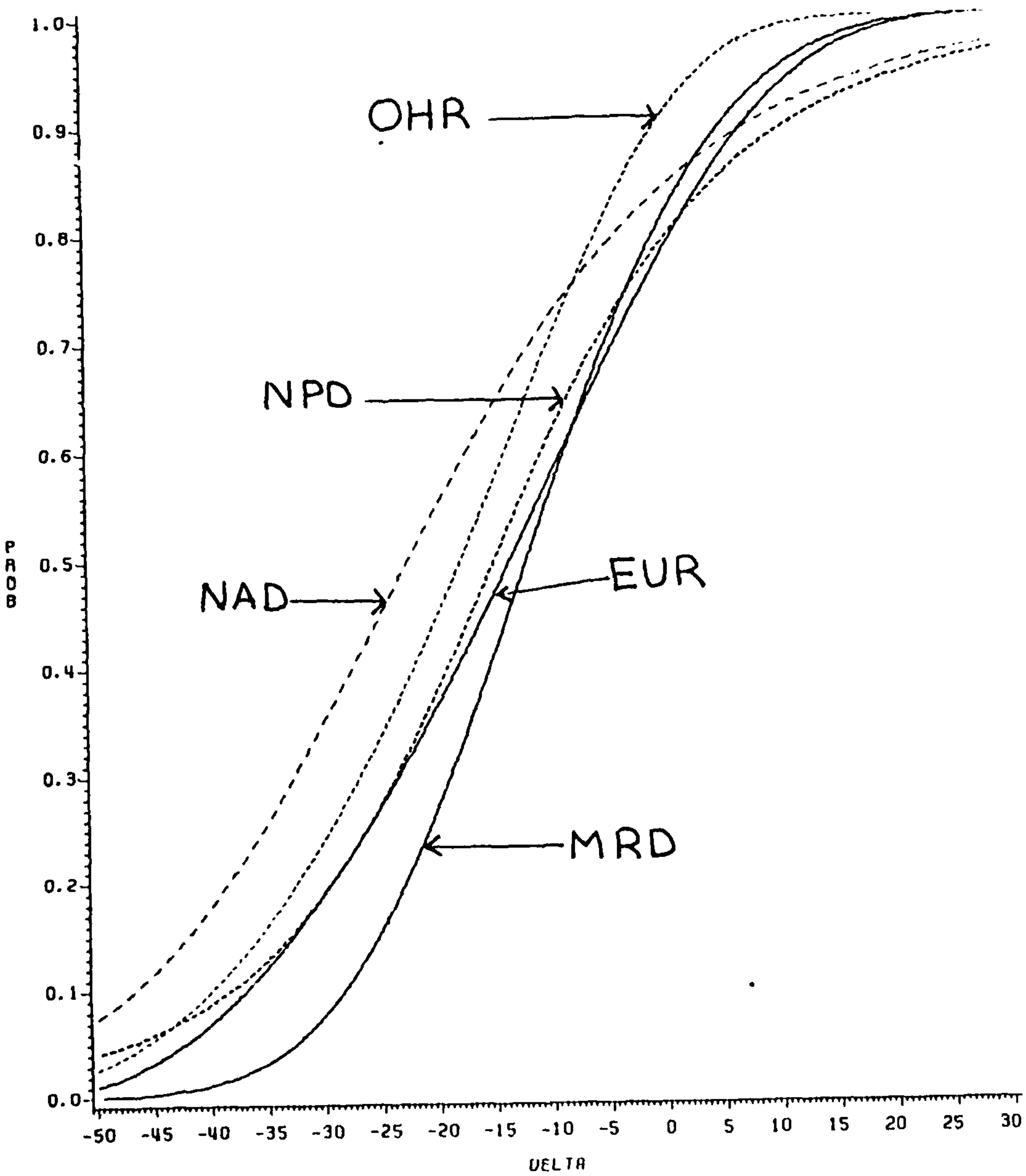


FIGURE 3.6: CDF OF DELTA OVERLAID

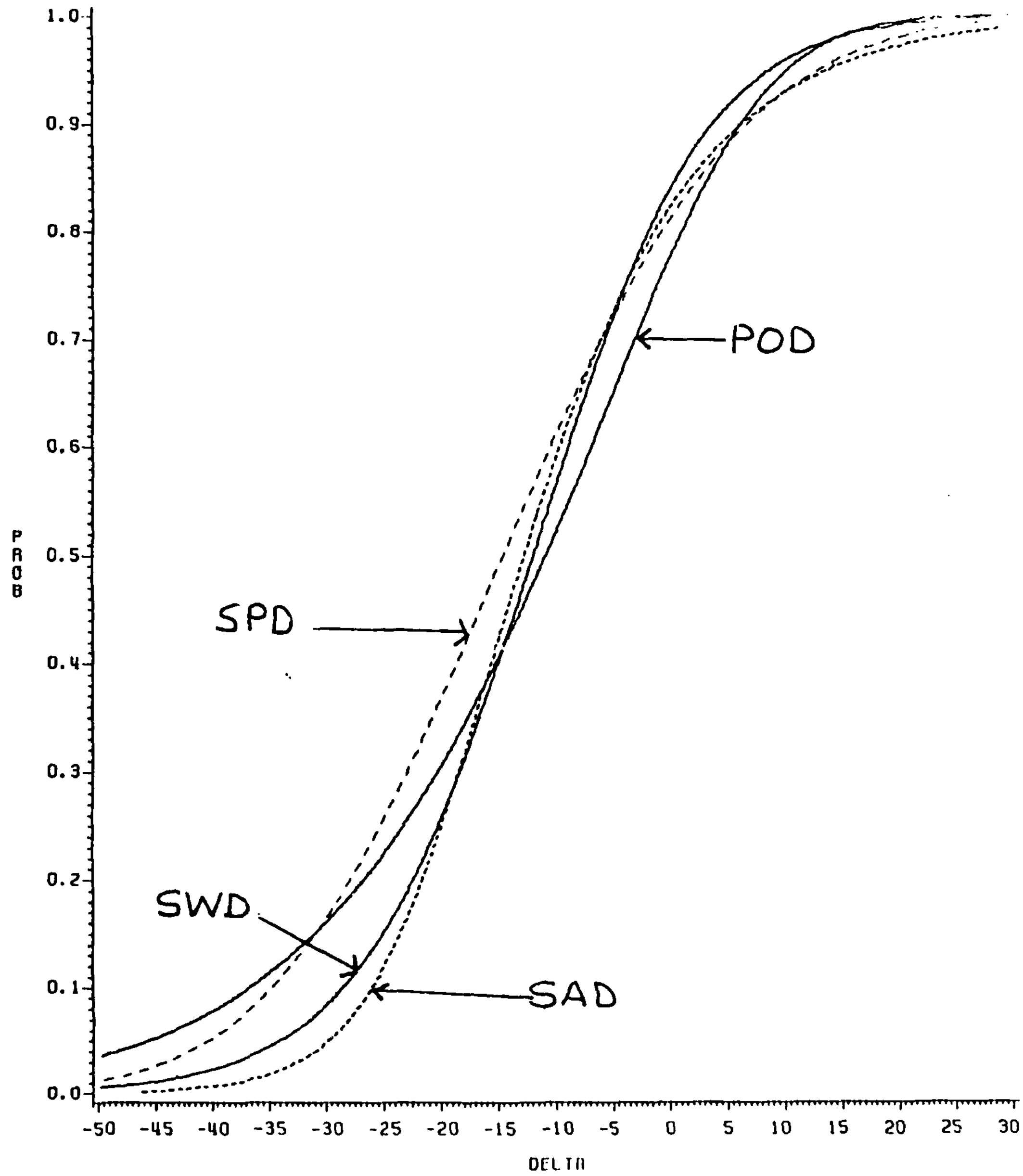


FIGURE 3.7: CDF OF DELTA OVERLAID

CHAPTER IV

SUMMARY AND CONCLUSIONS

4.1 SUMMARY OF ANALYSIS

As reported in Section 3.2 and 3.3, descriptive statistics for DELTA and DELTA1 were calculated and compared for all the data combined, and for each Engineer Division. The error was characterized before and after modeling with descriptive statistics. The plots of the cumulative density functions of the estimating error before and after modeling support the notion of slight improvement. Divisional Modeling also supported the notion of slight improvement in the variation of the estimating error. Pooling the residuals of Divisional Modeling and comparing them with the residuals of grand modeling, indicate a slight reduction in the variance of estimating error as measured by DELTA and DELTA1.

4.2 MAJOR CONCLUSIONS WITH REGARDS TO RESEARCH OBJECTIVES

The major conclusions on each research objective will be presented in this section.

4.2.1 QUANTITATIVE DESCRIPTION OF CURRENT ESTIMATING PRACTICE

There appears to be more variation in the estimating error of the Corps of Engineers than originally expected by this author. Prior to this study, any variation in excess of plus or minus 30% would have been thought to be excessive. The range of the error in the data set, 216%, before modeling, is extremely large and indicates a problem area that needs to be researched and improved upon. Of great concern is the inconsistency of the error, as there appears to be no pattern of consistent under or overestimating. The estimating error present in each Division is also excessive. Some of the Engineer Divisions have smaller variations of error than others, but all would benefit from study of current methods and practice to reduce this severe variability of estimating error.

Comparison of both DELTA and DELTA1, before and after modeling, indicate that there is a difference in the mean error before and after modeling, as would be expected. Comparison of the mean and standard deviation of DELTA and DELTA1, fail to indicate a change in the mean error of these two measures of error, either before or after modeling. This author concludes that there is no significant benefit in the use of DELTA1 as a measure of estimating error as compared to the more

conventional measure DELTA. Use of DELTA as a measure of estimating error should not be abandoned in favor or DELTA1.

4.2.2 LARGE SCALE ADJUSTMENTS TO COMPENSATE FOR ERROR

The overall mean error in each Engineer Division and Corps-wide is measure of the bias of the estimating effort. In all cases, the bias was overestimation bias. If this bias had a small variability associated with it (and this was consistently over or under the final estimate) a large scale adjustment could be used to correct the estimate. However, in the Corps of Engineer Data, such consistency of error is not found. With a range of error that is present, any large scale adjustment would help our estimating error average to zero error, but would not help much with individual projects. A significant reduction in the range or spread of estimating error is needed. Consistency in estimating is needed, regardless of direction. Once a consistent pattern is developed and the range of error reduced, then large scale adjustments and unbiasing techniques can be applied. At this point, there is too much variance in the data even after our modeling effort, to effect much change by unbiasing the estimating error.

4.2.3 BASELINE FOR FUTURE STUDY

The models presented in this thesis, for both individual Engineer Division and Corps-wide, give a starting position to analyze any improvement techniques implemented to correct the variation and bias of estimating error. This can be linked with the quantitative description of error, to form a "before improvement" picture of estimating practice. This characterization of the estimation effort can be compared to an "after improvement implemented" to see if results were significant. Ideally, information would be collected and analyzed up until the time of implementation of the new techniques. This information would be compared with the post-improvement information, to see if the estimating accuracy improved. The techniques and methodology of quantitatively describing the data and modeling would be useful to the Corps of Engineers or any of its Divisions, attempting to improve in this area.

4.3 MAJOR RECOMMENDATIONS FOR FUTURE RESEARCH

1. Examine and explore methods to aid in the standardization of estimating procedure, to improve estimating accuracy.
2. Explore changes of error over time, as in Kossuth (2) and Baswari (1).
3. Consider and explore statistical packages available for use on a microcomputer, so as to enable this methodology to be useful to industry.
4. Gather more specific data on each project.
5. Develop a specific coding scheme to classify projects into type of work, for entrance of that variable into the model.
6. Obtain similar data from private industry to validate both the methodology and the models in this study, for use with private industry needs.
7. Explore Larew's theory of social biasing of estimates with this and other data sets more fully.

BIBLIOGRAPHY

1. Baswari, Mohammed. "Investigation of the Schechtman-Wolfe Multi- Changepoint Procedure in Detecting SIV Changepoints in Construction Cost Indices". M.S. Thesis, The Ohio State University, 1983.

2. Kossuth, Craig L. "Non-Parametric Technique for Identifying a Change in Performance". M.S. Thesis, The Ohio State University, 1982.

3. Larew, Richard E. "Cost Estimating and Pricing in a Construction Company, Volume 2, Initial Stochastic Studies". Construction Engineering and Management, Department of Civil Engineering, The Ohio State University, 1976.

4. ---------------- Lecture Notes. Civil Engineering 882: Stochastic Construction Estimating. The Ohio State University, Spring Quarter, 1984.

5. Mendenhall, William and McClave, James T. A Second Course in Business Statistics: Regression Analysis. San Francisco: Dellan Publishing Company, 1981.

6. Ricer, T.L. "Accounting for Non-Normality and Sampling Error in the Analysis of Variance of Construction Data". M.S. Thesis, The Ohio State University, 1980.

7. SAS User's Guide: Basics. Raleigh, North Carolina: SAS Institute Inc., 1982.

8. SAS User's Guide: Statistics. Raleigh, North Carolina: SAS Institute Inc., 1981.

9. SAS Graph User's Guide. Raleigh, North Carolina: SAS Institute Inc., 1981.

10. Selim, Mohammed Y. "Assessment of Current Methods for Evaluating Estimating Accuracy". M.S. Thesis: The Ohio State University, Columbus, Ohio, 1982.

11. U.S. Army Corps of Engineers Recent Bid Experience-Military Construction Activity Report. Office of the U.S. Army Chief of Engineers, Washington, D.C.

12. Veselnak, John. "An analysis of Estimating Accuracy of Government Construction Contracts." M.S. Thesis: The Ohio State University, 1981.

APPENDIX A

LIST OF ORIGINAL DATA

Table A.1 gives the original data used in this study.

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC		DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMI
638	EUR	ALTER BLDG	29NOV83	6	0.237	0.215	0.49
639	SAD	PHYSICAL FITNESS CN	30NOV83	5	1.975	1.818	2.80
640	SWD	TRNG SUPPORT WHSE	01DEC83	9	0.536	0.443	0.60
641	NAD	SATELLITE TERM FAC	01DEC83	12	1.230	1.075	1.25
642	EUR	BARRACKS W/DINING	01DEC83	10	1.414	1.279	2.37
643	EUR	FACS MOD	01DEC83	15	1.549	1.366	2.30
644	EUR	DINING BKS CONV	01DEC83	9	2.561	2.364	4.35
645	EUR	TACT EQUIP SHOP	06DEC83	19	9.354	8.941	13.80
646	EUR	AUTO CTRLS-ECIP	08DEC83	9	0.438	0.349	0.76
647	OHR	REARM CONSOL MAN	08DEC83	9	13.598	12.711	22.00
648	NAD	WEAPONS MAINT FAC	13DEC83	21	8.168	4.792	8.90
649	NPD	BRIGADE HQ	13DEC83	15	0.805	0.906	1.50
650	EUR	RECREATION CENTER	13DEC83	15	0.923	0.893	1.15
651	SAD	MISSLE SYS SOFTWARE	14DEC83	8	11.262	6.894	16.00
652	POD	POL TANK RELOCATION	15DEC83	17	0.844	1.132	1.40
653	NPD	BARRACKS-MLRS	16DEC83	13	1.402	1.283	1.74
654	EUR	FAC MODERNIZATION	16DEC83	14	3.742	3.539	5.40
655	NAD	COMM CTR ADD/ALT	20DEC83	6	1.512	1.122	1.65
656	NAD	FOOD SERVICE TRNG	20DEC83	13	4.190	3.576	5.30
657	NPD	BN HQ & CLASSROOM	20DEC83	15	1.159	0.965	1.45
658	SAD	CHILD CARE CENTER	21DEC83	5	3.049	3.009	4.40
659	NPD	TACT EQUIP SHOP	21DEC83	9	3.101	3.199	7.80
660	NAD	MAINT FAC	21DEC83	5	6.754	5.999	7.20
661	SAD	METROLOGY/CALIB LAB	21DEC83	6	1.630	1.194	2.60
662	POD	TACT EQUIP SHOP	22DEC83	16	2.525	2.489	5.10
663	MRD	PHYSICAL FITNESS CN	28DEC83	10	3.128	3.000	3.55
664	SAD	PINK WATER SYS	04JAN84	8	3.661	3.651	4.25
665	EUR	PHYSICAL FITNESS CN	16JAN84	5	1.687	1.650	2.65
666	POD	TACT EQUIP SHOP	17JAN84	2	4.384	4.290	6.20
667	NAD	RENOVATE BLDG	18JAN84	10	0.958	0.918	0.91
668	MRD	UTILITIES-MUSAAF	19JAN84	7	5.122	4.652	5.40
669	EUR	BN HQ W/CLASSROOM	19JAN84	14	1.010	0.786	1.75
670	EUR	ATTIC INSUL	19JAN84	5	0.589	0.562	0.92
671	OHR	FLIGHT SIMULATOR	24JAN84	8	2.786	1.790	5.50
672	NAD	STEAM DIST SYS	24JAN84	12	5.025	4.344	3.95
673	MRD	SEWAGE TRMT PLANT	25JAN84	11	1.243	1.072	1.15
674	SPD	COMMUNICATION&ADP	30JAN84	7	1.453	1.074	1.90
675	EUR	PHYS FITNESS CTR	31JAN84	10	1.630	1.500	2.45
676	EUR	PHYS FITNESS CTR	31JAN84	7	0.405	0.353	0.76
677	EUR	PHYS FITNESS CTR	01FEB84	8	0.989	0.973	1.55
678	SPD	COMMUNICATIONS CTR	01FEB84	11	0.897	1.087	1.75
679	NPD	CORRECT OSHA DEF	02FEB84	10	0.883	1.035	2.65
680	NAD	BARRACKS MOD	03FEB84	12	7.042	5.468	8.10
681	EUR	FACS MOD	07FEB84	14	3.823	3.163	4.55
682	SWD	BRADLEY VEH SPT FAC	07FEB84	12	1.713	1.484	1.25
683	EUR	PHYS FITNESS CTR	14FEB84	19	1.386	1.264	2.55
684	EUR	ATC EQUIP SHOP	16FEB84	10	1.177	1.153	1.60
685	EUR	BARRACKS	16FEB84	13	2.366	1.992	3.25
686	NPD	RANGE & TRNG FAC IP	21FEB84	10	0.831	0.938	0.94

TABLE A.1 - ORIGINAL DATA
(Continued)

	LOC	DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMT
589	SPD	BDS GROUND SIMUL FC	28JUL83	6	0.350	0.323	0.290
590	NAD	CEILING INSUL	04AUG83	21	0.177	0.059	0.212
591	EUR	RIPPLE CONTROL	16AUG83	9	0.335	0.421	0.292
592	EUR	HTG BLDG 4172	31AUG83	2	0.314	0.373	0.303
593	EUR	HELIPADS	06SEP83	11	0.411	0.344	0.403
594	SPD	E BLOCK DRAINAGE	12SEP83	3	1.026	0.612	0.726
595	OHR	AMME FACLIITY	13SEP83	13	0.326	0.213	0.354
596	NAD	COMPUTER FAC	16SEP83	8	0.370	0.270	0.337
597	EUR	GDAAC BLDG	19SEP83	4	0.155	0.146	0.258
598	NAD	CHEM CHANGEHOUSE	02NOV82	7	0.676	0.568	0.703
599	EUR	WASTE BURNING FAC	16DEC82	2	0.130	0.165	0.120
600	EUR	CHANGEHOUSE	17DEC82	9	0.496	0.401	0.481
601	EUR	TOXIC CHEM FAC	27DEC82	9	0.560	0.453	0.555
602	MRD	CHEM CHANGEHOUSE	08MAR83	8	0.565	0.535	0.629
603	EUR	ENGINE TEST CELLS	23MAY83	6	0.273	0.305	0.370
604	SAD	EMCS EXTENSION	23JUN83	5	0.048	0.044	0.053
605	EUR	GEN INST BLDG	30JUN83	6	0.328	0.270	0.429
606	EUR	INDOOR FIRING RANGE	02SEP83	3	0.190	0.209	0.327
607	NAD	PACK SHIP REC FAC	12SEP83	4	0.298	0.324	0.390
608	NAD	TOXIC MUN CHG HOUSE	19SEP83	5	0.394	0.397	0.481
609	SAD	CO ADMIN & SUPPLY	02SEP83	3	0.667	0.550	1.500
610	NPD	FLIGHT SIMULATOR	20OCT83	14	5.011	2.984	8.000
611	SWD	WEAPONS TRAINING FC	27OCT83	11	2.095	1.450	2.150
612	EUR	ADMIN BLDG MLRS	08NOV83	11	0.453	0.361	0.750
613	EUR	BARRACKS	08NOV83	13	1.282	1.161	2.350
614	EUR	BARRACKS	06NOV83	13	3.036	3.394	6.300
615	EUR	TACT EQUIP SHOP	08NOV83	10	1.385	1.161	2.150
616	NAD	WEATHERSTRIPPING	08NOV83	10	0.335	0.119	0.450
617	EUR	TACT EQUIP SHOP	10NOV83	9	2.847	2.781	3.100
618	EUR	FACILITIES MOD	10NOV83	16	3.951	3.222	5.700
619	SWD	TRNG FAC-JSTARS	15NOV83	12	0.474	0.392	0.650
620	NAD	RECREATION CTR	17NOV83	12	1.489	1.447	1.500
621	SAD	FLIGHT SIMULATOR	17NOV83	3	1.773	1.352	3.050
622	SAD	ELEC DIST SYS	17NOV83	11	2.063	0.486	3.000
623	EUR	AMMO STORAGE-DIVAD	17NOV83	11	1.183	0.865	2.550
624	EUR	FIN/PERSONNEL CTR	18NOV83	12	1.014	0.833	1.800
625	EUR	ATC EQUIP SHOP	18NOV83	15	6.844	5.626	11.800
626	EUR	TACT EQUIP SHOP MOD	22NOV83	17	2.614	2.105	2.550
627	EUR	HARDSTAND	22NOV83	18	0.226	0.227	0.340
628	POD	UPGRADE POL STORAGE	22NOV83	11	0.999	0.590	2.000
629	NAD	ENERGY EFFICIENT LT	22NOV83	10	0.200	0.119	0.360
630	NPD	CO ADMIN & SUPPLY	23NOV83	13	2.993	2.133	4.250
631	NPD	BN HQ & CLASSROOM	23NOV83	13	2.449	1.722	2.800
632	EUR	BARRACKS MOD	24NOV83	17	6.849	5.842	6.600
633	EUR	ABBRACKS W/DINING	25NOV83	16	4.245	3.801	7.100
634	SWD	CO ADMIN & SUPPLY	29NOV83	10	1.804	1.633	2.200
635	SWD	BN CLASSROOM	29NOV83	10	0.474	0.426	0.530
636	SAD	DINING FACS MOD	29NOV83	6	1.271	1.471	1.800
637	SAD	STEAM DIST SYS	29NOV83	16	4.686	4.313	6.500

TABLE A.1 - ORIGINAL DATA
(Continued)

	LOC	DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMI
540	EUR	WADS	30AUG83	13	2.852	2.299	5.000
541	NRD	EMCS	01SEP83	6	.	1.902	1.372
542	EUR	FAC MOD	09SEP83	10	3.962	3.557	6.000
543	NAD	EMCS	15SEP83	9	1.213	0.560	1.035
544	POD	A/C FUEL STG	23SEP82	14	0.470	0.598	0.492
545	NAD	ADDN TO MAIN GATE	18OCT82	11	0.088	0.145	0.168
546	SAD	WEAPONS TRNG FAC	03NOV82	7	0.348	0.265	0.321
547	SWD	MOVING TGT	30NOV82	11	0.439	0.471	0.391
548	POD	STANDBY GEN	03DEC82	2	0.187	0.146	0.187
549	SWD	CONSEC SPT DET FAC	08DEC82	9	0.360	0.340	0.387
550	SWD	VET FACILITY	16DEC82	4	0.399	0.448	0.266
551	NRD	NEO-NATAL ICU	20DEC82	7	0.456	0.467	0.485
552	EUR	HANGAR EXPANSION	21DEC82	6	0.278	0.262	0.351
553	EUR	EQUIP MAINT CTR	23DEC82	3	0.478	0.544	0.819
554	NAD	RANGE IMPROVEMENT	18JAN83	16	0.388	0.261	0.393
555	NPD	TACT EQUIP SHOP	04JAN83	21	0.326	0.233	0.300
556	EUR	READY BUILDING	19JAN83	12	0.160	0.164	0.323
557	NPD	LINEAR ACCELERATION	01FEB83	15	0.382	0.334	0.495
558	SPD	TSFO CLASSROOM	02FEB83	9	0.246	0.270	0.301
559	EUR	READY BUILDING	16MAR83	12	0.117	0.131	0.271
560	EUR	READY BUILDING	16MAR83	12	0.092	0.111	0.281
561	EUR	EP MESS FACILITY	17MAR83	7	0.373	0.160	0.260
562	NRD	ADD TO ADP BLDG 30	30MAR83	15	0.461	0.473	0.543
563	SWD	ALT VET CLINIC	12APR83	9	0.303	0.280	0.357
564	NAD	SIT PREP POR EQ IN	26APR83	7	0.279	0.172	0.313
565	POD	TSFO FAC	29APR83	3	0.423	0.369	0.598
566	NAD	COM SUPPORT CTR	03MAY83	12	0.585	0.518	0.646
567	SAD	VEHICLE MECH COURSE	10MAY83	14	0.691	0.736	0.734
568	SWD	ENT CLINIC ALT	11MAY83	8	0.201	0.192	0.288
569	NAD	INITIAL OPS FAC	12MAY83	19	0.613	0.172	0.565
570	POD	MILES WAREHOUSE	12MAY83	17	0.438	0.389	0.607
571	NAD	AD FUNCTIONAL FIRE	17MAY83	11	0.756	0.614	0.834
572	SPD	AD ASARS FAC	17MAY83	14	0.526	0.438	0.383
573	SWD	WATER PUMP STATION	19MAY83	7	0.575	0.535	0.760
574	SWD	BULK STORAGE	25MAY83	14	0.467	0.419	0.413
575	SPD	FIRING RANGE	26MAY83	7	0.455	0.436	0.989
576	NRD	BKS IMPROVEMENT	01JUN83	8	0.429	0.419	0.561
577	SWD	PARACHUTE RIGGING	02JUN83	13	0.401	0.379	0.496
578	NAD	SUPPLY & EQUIP ADDN	02JUN83	13	0.276	0.200	0.298
579	EUR	APPLIED INSTRUCT BD	08JUN83	6	0.117	0.150	0.214
580	NRD	CARDIAC CATHETER LB	10JUN83	2	0.368	0.387	0.425
581	NAD	LAUNDRY BOILER PLNT	15JUN83	13	0.249	0.365	0.279
582	NAD	HOT METAL FAC	21JUN83	9	0.478	0.413	0.500
583	NRD	USDA SEC	23JUN83	6	0.773	0.894	0.992
584	SWD	RANGE	30JUN83	9	0.623	0.475	0.796
585	SWD	WATER TREAT FAC	07JUL83	8	0.445	0.460	0.425
586	EUR	COMMUNICATIONS CTR	12JUL83	5	0.455	0.174	0.579
587	SAD	RFSS-IESS SPT FAC	19JUL83	17	0.326	0.250	0.480
588	NAD	MAINT TRAIN FAC	22JUL83	7	0.547	0.642	0.867

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC		DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAML
491	SWD	TACT EQUIP SHOP	01SEP83	4	2.333	2.040	2.950
492	OHR	TANK DRIVING COURSE	01SEP83	8	2.475	1.948	2.900
493	SWD	TRAINEE BKS	02SEP83	16	17.678	15.298	20.000
494	SAD	EM BKS	02SEP83	3	4.600	4.900	5.800
495	EUR	BOQ	06SEP83	6	1.490	0.701	2.300
496	EUR	GYM	06SEP83	6	1.375	0.540	2.200
497	EUR	WATER SUPPLY	07SEP83	5	0.240	0.186	0.610
498	OHR	SANITARY LANDFILL	08SEP83	12	1.711	1.656	3.000
499	MRD	RADIO THERAPY	12SEP83	6	0.567	0.526	0.595
500	MRD	ALTER BLDG 500	12SEP83	4	0.529	0.525	0.534
501	EUR	TRAINING AREA	14SEP83	5	0.564	0.779	0.722
502	SWD	ELECTRIC SHOP	14SEP83	6	0.457	0.350	0.390
503	EUR	MAINT FAC & HARDSTD	14SEP83	11	0.754	0.629	0.871
504	OHR	COMPUTER FAC	15SEP83	4	0.553	0.479	0.658
505	EUR	TACT EQUIP SHOP	16SEP83	9	1.408	1.325	2.100
506	SWD	DIVISION HQ	16SEP83	8	10.226	8.879	13.500
507	OHR	TACT EQUIP SHOP	21SEP83	6	2.383	2.130	3.200
508	SPD	OSHA DEFICIENCIES	21SEP83	3	1.940	1.515	2.100
509	NPD	RANGE & FAC IMPRV	21SEP83	3	1.361	1.189	1.350
510	EUR	BARRACKS	22SEP83	12	1.498	1.498	3.650
511	SPD	TACT EQUIP SHOP	23SEP83	7	2.300	2.125	3.200
512	OHR	EXT STEAM DIST SEP	05OCT82	12	0.869	0.549	0.710
513	EUR	HEALTH CLINIC	18NOV82	10	0.035	0.094	0.150
514	EUR	HW CONVERSION	02DEC82	5	0.102	0.111	0.410
515	EUR	AUTO HTG SYS	15DEC82	8	1.813	1.475	2.400
516	EUR	HEATING PLANT	12JAN83	17	4.228	3.985	4.342
517	EUR	STEAM CONVERSION	20JAN83	7	0.119	0.092	0.102
518	EUR	ACRFT MAINT HANGAR	20JAN83	22	2.205	1.741	2.372
519	EUR	RANGE UPGRADE	25JAN83	9	0.430	0.457	1.211
520	EUR	REHAB BEQ	28JAN83	18	[illegible]	1.935	1.331
521	EUR	AMMO IGLOOS	02FEB83	14	0.317	0.281	0.300
522	EUR	TACT EQUIP SHOP	24FEB83	19	2.441	1.710	5.100
523	EUR	ECIP CONTROLS	15MAR83	10	0.126	0.069	0.717
524	NAD	UPGRD SCTY SYS	15MAR83	2	3.116	2.689	4.300
525	NAD	PHYSICAL DVLPMNT CT	16MAR83	16	16.014	15.763	17.960
526	SPD	MOD SEWAGE TR PLANT	05APR83	13	1.941	1.749	2.100
527	EUR	ACCESS ROAD	05MAY83	6	0.153	0.168	0.500
528	NAD	EMISSION CNTRL BOIL	11MAY83	14	2.012	1.382	1.900
529	EUR	MAINT SHOP	17MAY83	6	0.906	0.855	4.370
530	EUR	AUTO CONTROLS	25MAY83	4	0.061	0.061	1.036
531	EUR	TACT EQUIP SHOP	26MAY83	15	4.659	4.116	7.100
532	MRD	HYDROLOGICAL BARR	22JUN83	6	3.146	2.642	5.100
533	SAD	REGIONAL SEWER	30JUN83	17	6.942	6.505	5.503
534	EUR	DRAIN & SEWER	20JUL83	16	0.450	0.383	0.800
535	EUR	INCINERATOR	28JUL83	6	0.468	0.356	0.500
536	NAD	PK, SHIP REC FAC	09AUG83	6	0.912	0.654	0.540
537	EUR	WATER PUR PLT	15AUG83	7	1.805	1.889	2.550
538	EUR	FAC MOD	19AUG83	7	7.227	5.784	6.767
539	EUR	WADS	30AUG83	13	3.954	3.340	5.000

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC		DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMT
442	SAD	SIGNAL SCHOOL	16JUN83	14	5.699	4.859	9.200
443	EUR	POWER UPGRADE	16JUN83	7	0.470	0.544	0.800
444	NAD	INSTALL ECONOMIZER	21JUN83	12	0.270	0.244	0.300
445	EUR	HEATING SYSTEM CONV	21JUN83	2	0.417	0.432	0.440
446	EUR	BKS W/ADMIN	21JUN83	10	1.045	0.972	2.200
447	SAD	BARRACKS	23JUN83	15	11.554	10.454	15.470
448	SAD	CO ADMIN & SUPPLY	23JUN83	15	1.143	1.000	2.050
449	MRD	TACT EQUIP SHOP	28JUN83	5	1.189	1.248	1.550
450	SWD	TACT EQUIP SHOP	08JUL83	4	1.617	1.680	1.640
451	SWD	TACT EQUIO SHOP	08JUL83	4	3.502	3.588	5.500
452	EUR	UPGRD CUSTODIAL FAC	12JUL83	9	0.348	0.124	0.570
453	EUR	UPGRD CUSTODIAL FAC	12JUL83	9	0.266	0.048	0.350
454	EUR	BKS & BOQ	12JUL83	9	0.999	0.568	1.450
455	EUR	ADMIN BLDG	12JUL83	9	0.995	0.238	1.100
456	MRD	HOSPITAL UPGRADE	13JUL83	6	9.314	7.947	13.600
457	EUR	MAINT SHOP	21JUL83	11	0.208	0.485	0.593
458	SWD	TACT EQUIP SHOP	21JUL83	17	6.894	5.761	8.400
459	SWD	TACT EQUIP SHOP	21JUL83	17	4.732	3.514	6.200
460	EUR	BARRACKS	21JUL83	16	4.028	3.311	7.600
461	SAD	SEWAGE TRMT EXT	21JUL83	6	0.940	0.511	1.250
462	SAD	WATER DIST SYSTEM	21JUL83	6	0.978	0.831	1.000
463	SAD	ROAD NET & DRAIN	21JUL83	6	6.419	5.858	8.300
464	EUR	COAL FIRED HTG PLNT	21JUL83	11	1.045	0.315	0.601
465	SWD	TACT EQUIP SHOP	26JUL83	10	3.189	2.809	4.100
466	MRD	COMBINED RANGE	27JUL83	6	2.399	1.955	2.500
467	SAD	DECON TRNG FAC	03AUG83	17	13.561	9.029	7.500
468	EUR	TACT EQUIP SHOP	05AUG83	9	1.162	1.011	2.300
469	POD	CONS COM CTR	09AUG83	7	3.021	3.426	4.100
470	EUR	MAINT FAC	09AUG83	9	0.687	0.680	1.200
471	SAD	RANGE UPGRADE	10AUG83	4	1.520	1.636	1.950
472	SWD	CONTAIN HAZ CHEM	11AUG83	9	0.596	0.444	0.500
473	SPD	CO ADMIN & SUPPLY	11AUG83	7	0.527	0.497	0.550
474	SAD	GORGAS HOSPITAL	12AUG83	2	2.211	2.199	2.650
475	EUR	HTG PLANT	16AUG83	8	0.160	0.143	1.015
476	EUR	HTG PLANT	16AUG83	6	0.026	0.026	0.203
477	EUR	ELECTRIC SUBSTA	16AUG83	6	0.060	0.056	0.232
478	EUR	SECURE PARKING	18AUG83	13	0.287	0.499	0.613
479	EUR	SECURE PARKING	18AUG83	13	0.287	0.400	0.648
480	SAD	TRAINEE BKS W/DININ	18AUG83	5	7.396	7.115	9.700
481	SAD	COMMAND & CTRL HQ	18AUG83	11	34.100	29.212	41.000
482	EUR	MOTOR REPAIR SHOP	18AUG83	6	0.349	0.281	0.830
483	EUR	BARRACKS	19AUG83	6	5.482	5.490	12.200
484	EUR	PATRIOT IRP	19AUG83	7	0.524	0.387	0.460
485	OHR	TACT EQUIP SHOP	23AUG83	7	3.097	2.736	3.200
486	SAD	POST OFFICE	24AUG83	4	0.213	0.117	0.270
487	SAD	HEALTH CLINIC	24AUG83	4	0.667	0.644	1.050
488	SAD	IFV RANGES	25AUG83	9	12.567	13.067	15.500
489	SAD	TACT EQUIP SHOP	25AUG83	7	3.984	3.509	5.700
490	SWD	DINING FAC MOD	25AUG83	8	0.799	0.687	0.980

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC		DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMI
393	OHR	FLIGHT SIMULATOR	15MAR83	11	2.234	1.925	2.85
394	SAD	BARRACKS	15MAR83	14	9.287	6.523	11.70
395	SAD	CO ADMIN & SUPPLY	15MAR83	14	1.331	0.811	2.10
396	SAD	DINING FAC	15MAR83	14	1.316	0.826	1.65
397	SWD	MAINT MOD	16MAR83	15	23.634	18.430	29.00
398	SPD	SATELLITE CTRL FAC	18JAN83	11	2.052	1.826	2.05
399	NAD	OBS FIRE TR FAC	18JAN83	16	0.295	0.410	0.32
400	NAD	GYM ADDITION	19JAN83	18	0.444	0.400	0.49
401	EUR	BARRACKS	19JAN83	12	2.800	2.380	5.10
402	EUR	SQUAD QUAL RANGE	25JAN83	9	0.101	0.093	0.50
403	EUR	PLT QUAL RANGE	25JAN83	9	0.135	0.159	1.50
404	POD	AIRCRAFT HANGAR	01FEB83	8	18.903	12.802	20.00
405	EUR	HOSPITAL RENOVATE	02FEB83	12	13.486	10.110	29.00
406	SPD	BARRACKS	03FEB33	13	1.770	1.978	2.20
407	NAD	COMM SYS FAC	10FEB83	12	1.580	0.926	1.70
408	EUR	BARRACKS	10FEB83	21	1.130	1.032	2.05
409	SWD	CO ADMIN & SUPPLY	10FEB83	10	4.005	3.684	4.30
410	SWD	BN HQ & CLASSROOM	10FEB83	10	2.322	2.183	2.45
411	EUR	DEF COM SYS	16FEB83	10	1.444	1.610	3.95
412	MRD	ENERGY CONS	23FEB83	3	0.488	0.305	0.85
413	EUR	TACT EQUIP SHOP	23FEB83	9	1.922	1.764	3.35
414	OHR	ADDN ELEC PWR BLDG	23FEB83	8	0.544	0.492	0.63
415	EUR	BARRACKS	23FEB83	9	5.146	4.272	10.40
416	SAD	BARRACKS MOD	16MAR83	5	1.937	1.863	2.80
417	SAD	BARRACKS MOD	17MAR83	3	1.134	0.989	1.35
418	SWD	ELECTROMAG TEST FAC	24MAR83	15	3.393	2.395	4.95
419	MPD	BN AC PARK APRON	24MAR83	9	1.400	1.324	2.80
420	MRD	GENERAL INST BLDG	31MAR83	8	4.701	4.830	4.20
421	EUR	FAC MOD	27APR83	8	3.462	2.537	5.80
422	EUR	AUTO CTRLS-ECIP	04MAY83	6	0.909	0.869	1.25
423	SPD	TRAINING RANGES	05MAY83	20	1.137	0.803	1.54
424	SPD	TACT EQUIP SHOP	10MAY83	8	0.411	0.424	0.99
425	EUR	AUTO CONTROLS-ECIP	10MAY83	15	1.059	0.891	1.85
426	MRD	RR LOADING AREA	12MAY83	7	2.850	2.533	2.80
427	MRD	ACCESS ROAD	12MAY83	7	0.768	0.668	1.85
428	MPD	COBRA FIRING RANGE	17MAY83	11	1.024	0.965	1.25
429	SWD	CHILD CARE CENTER	19MAY83	12	2.132	2.110	2.60
430	POD	TACT EQUIP SHOP	19MAY83	19	1.836	1.549	2.93
431	MPD	CONTROL TOWER	26MAY83	6	1.381	1.334	1.67
432	MRD	MAINT DIV COMPLEX	26MAY83	8	8.660	6.577	11.00
433	EUR	DINING FAC-ECIP	26MAY83	3	0.383	0.351	0.44
434	EUR	TACT EQUIP SHOP	01JUN83	25	2.929	2.286	5.00
435	EUR	TACT EQUIP SHOP	01JUN83	25	3.950	2.857	4.84
436	NAD	INSULATE 300/400 AR	08JUN83	19	1.178	0.775	1.55
437	EUR	BARRACKS	14JUN83	9	6.307	6.326	14.60
438	EUR	TACT EQUIP SHOP	14JUN83	9	0.242	0.243	1.25
439	EUR	AMMO STGE IGLOOS	14JUN83	13	0.668	0.632	0.68
440	POD	CONTROL ELEC SUBSTA	15JUN83	8	0.574	0.402	0.63
441	EUR	HVAC UPGRADE	16JUN83	7	0.283	0.328	0.95

TABLE A.1 - ORIGINAL DATA
(Continued)

	LOC	DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMT
344	EUR	NBC DECON TNG CTR	02OCT82	17	0.991	0.639	1.65
345	EUR	BARRACKS	16NOV82	17	1.456	1.268	3.45
346	EUR	TRAINING FAC	16NOV82	7	3.482	2.828	8.70
347	EUR	BARRACKS-DIVAD	16NOV82	17	1.942	1.605	3.95
348	EUR	STGE MAINT	16NOV82	22	1.041	0.711	1.10
349	EUR	TACT EQUIP SHOP	23NOV82	9	4.039	3.841	7.10
350	EUR	MAINT SPT FAC	24NOV82	10	3.191	2.631	6.30
351	EUR	TACT EQUIP SHOP	24NOV82	15	0.652	0.577	0.92
352	EUR	BARRACKS	24NOV82	19	0.973	0.745	2.10
353	EUR	BARRACKS	24NOV82	21	2.368	1.872	5.80
354	MRD	INSULATE BLDGS	02DEC82	6	0.387	0.341	0.55
355	EUR	ATTIC INSULATION	02DEC82	9	1.139	0.739	1.85
356	SPD	VEH MAINT FAC	09DEC82	16	1.349	1.151	2.10
357	EUR	FLT SIM BLDG	10DEC82	11	3.224	2.700	7.30
358	EUR	BARRACKS W/DINING	10DEC82	10	0.597	0.684	1.10
359	EUR	AMMO STORAGE	14DEC82	24	1.113	0.962	2.15
360	NAD	M1 TRNG FAC	15DEC82	16	7.831	3.795	9.40
361	NAD	AVIATION TNG FAC	15DEC82	17	3.639	3.024	6.40
362	SWD	BN HQ W/CLASSROOM	15DEC82	9	1.176	1.150	1.50
363	SWD	CO ADMIN&SUPPLY	15DEC82	9	1.733	1.547	2.35
364	EUR	AUTO TEMP CTRLS	16DEC82	4	0.344	0.365	0.72
365	EUR	WASTE OIL BURN FAC	16DEC82	2	0.130	0.164	0.12
366	NAD	BARRACKS W/DINING	16DEC82	15	9.948	8.479	13.80
367	SWD	HANGAR W/SHOPS	16DEC82	9	13.722	10.154	15.50
368	SPD	TROOP MED CLINIC	16DEC82	14	3.384	3.333	5.80
369	EUR	UPGRADE RANGE	21DEC82	4	0.241	0.218	0.26
370	EUR	BARRACKS	21DEC82	26	1.574	1.163	4.05
371	SAD	TACT EQUIP SHOP	21DEC82	5	0.290	0.322	0.57
372	NAD	SATELLITE CTRL FAC	21DEC82	20	2.282	1.070	2.50
373	SAD	TACTICAL EQUIP SHP	11JAN83	3	0.280	0.305	0.72
374	EUR	VEHICLE HARDSTAND	12JAN83	17	0.405	0.267	0.52
375	MRD	CO ADMIN & SUPPLY	12JAN83	17	0.319	0.261	0.44
376	SAD	DINING FAC MOD	17JAN83	7	0.265	0.205	0.36
377	EUR	NITE SETBACK CTRL	17JAN83	2	0.109	0.108	0.16
378	NAD	TRAINING AREA	24FEB83	15	2.875	2.343	3.20
379	NPD	HELICPOTER HANGAR	01MAR83	10	5.111	3.201	7.40
380	NPD	UNIT MAINT HANGAR	01MAR83	10	5.193	3.244	7.50
381	NPD	TACT EQUIP SHOP	02MAR83	21	2.348	1.339	2.90
382	NPD	TACT EQUIP SHOP	02MAR83	21	0.890	0.508	1.10
383	MRD	BN HQ W/CLASSROOM	02MAR83	12	1.256	1.039	1.45
384	MRD	CO ADMIN & SUPPLY	02MAR82	12	1.236	1.023	1.75
385	NPD	GYMNASIUM	03MAR83	8	0.974	0.886	1.70
386	SPD	ROAD IMPROVEMENTS	03MAR83	20	9.830	8.828	13.00
387	SWD	MAINT MOD	03MAR83	25	10.145	7.192	10.00
388	EUR	ENERGY CONSERVATION	03MAR83	9	0.604	0.497	1.15
389	MRD	BARRACKS	09MAR83	14	3.047	2.479	3.60
390	NAD	RENOV HVAC SYS	10MAR83	7	5.712	3.097	9.80
391	SAD	ELECT DIST REHAB	10MAR83	11	3.980	2.403	2.67
392	EUR	FACILITY MOD	10MAR83	23	1.319	1.031	2.45

TABLE A.1 - ORIGINAL DATA
(Continued)

	LOC	DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAM
295	SWD	SCIT	11AUG82	6	0.477	0.409	0.483
296	EUR	MSL MAINT FAC	20AUG82	4	0.195	0.194	0.251
297	OHR	MECH VENT-SAFETY DV	24AUG82	4	0.019	0.022	0.015
298	OHR	MECH VENT-SAFETY DV	25AUG82	6	0.192	0.178	0.161
299	OHR	ALT OIL FIRED HEAT	25AUG82	5	0.301	0.248	0.306
300	EUR	ALT SAN SEWER SYS	26AUG82	10	0.210	0.201	0.482
301	OHR	MECH VENT-SAFETY DV	31AUG82	6	0.099	0.089	0.083
302	MRD	CONT ABOVE GND TKS	01SEP82	6	0.255	0.158	0.290
303	OHR	MECH VENT-SAFETY DV	01SEP82	3	0.059	0.032	0.049
304	NAD	INSUL/STORM WINDOW	08SEP82	8	0.135	0.144	0.360
305	OHR	OPERATIONS CENTER	09SEP82	2	0.198	0.181	0.200
306	NAD	COLLECTION METHANE	20SEP82	2	0.210	0.170	0.269
307	EUR	HARDSTAND	10SEP82	3	0.271	0.329	0.357
308	EUR	HARDSTAND	14SEP82	6	0.166	0.143	0.321
309	OHR	AC ENG TEST FAC	14SEP82	5	0.459	0.373	0.463
310	EUR	BORDER OBS POST	16SEP82	4	0.095	0.113	0.121
311	EUR	BORDER OBS POST	16SEP82	4	0.088	0.105	0.113
312	EUR	BORDER OBS POST	16SEP82	4	0.098	0.120	0.184
313	EUR	BORDER OBS POST	16SEP82	4	0.198	0.218	0.246
314	SAD	OBS FIRE TRAINER	20SEP82	5	0.282	0.300	0.469
315	NAD	ALT FOR EDPC SYS	21SEP82	3	0.447	0.302	0.379
316	EUR	TNG SPT BLDG	21SEP82	13	0.249	0.266	0.462
317	NAD	WTR RECYCLE & VEH	22SEP82	6	0.134	0.146	0.161
318	NAD	CONV BLDG 320	17NOV81	9	0.138	0.125	0.158
319	MRD	ALTER MED INT CARE	30NOV81	6	0.368	0.327	0.464
320	POD	CONV BLDG 104	22DEC81	3	0.375	0.290	0.465
321	SAD	K.D. SNIPER RANGE	23DEC81	18	0.169	0.129	0.196
322	SAD	BEN COSCOM FAM FAC	29DEC81	11	0.145	0.141	0.191
323	SWD	WASTE WATER TMNT	12JAN82	2	0.369	0.318	0.369
324	OHR	ADJ FRESH AIR QUANT	21JAN82	4	0.150	0.096	0.200
325	NAD	TEMP LACV FAC	28JAN82	12	0.443	0.372	0.462
326	SPD	FIRE STATION ADDN	17FEB82	15	0.187	0.132	0.204
327	NAD	CHURHCVILLE TEST C	18FEB82	16	0.361	0.180	0.361
328	OHR	TMDE FAC	23FEB82	9	0.258	0.226	0.207
329	OHR	WATER MONITORING ST	25MAR82	7	0.171	0.159	0.220
330	EUR	MAINT FAC	04MAY82	9	0.296	0.273	0.381
331	EUR	GEN PURPOSE WHSE	12MAY82	12	0.400	0.380	0.475
332	SWD	ADDN WASHER/DRYER	18MAY82	8	0.315	0.274	0.341
333	MRD	ADDN/ALT LAB	03AUG82	3	0.278	0.309	0.265
334	NAD	REL MIL CLOTH STORE	03AUG82	9	0.149	0.097	0.200
335	OHR	ALT OIL FIRED HEAT	25AUG82	5	0.301	0.248	0.306
336	NAD	TROOP TEST MODULES	26AUG82	8	0.267	0.227	0.322
337	SAD	ROADWAY IMP	01SEP82	3	0.397	0.402	0.485
338	SWD	INTERIM A/C REFUEL	03SEP82	4	0.045	0.056	0.056
339	EUR	TRAILER PARKING	07SEP82	16	0.256	0.195	0.491
340	EUR	INSTALL HEAT CTRL	08SEP82	3	0.331	0.332	0.487
341	EUR	PARKING OF M-1	14SEP82	6	0.166	0.143	0.321
342	EUR	WATER SUPPLY SYS	16SEP82	3	0.290	0.349	0.413
343	SWD	MOD SHIP & REC BLDG	21SEP82	4	0.424	0.340	0.467

TABLE A.1 - ORIGINAL DATA
(Continued)

	LOC	DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMI
246	NAD	BOQ FIRE ALARM SYS	15APR82	10	0.069	0.029	0.139
247	SAD	FENCING HAWK-I	16APR82	3	0.030	0.022	0.400
248	NAD	VEHICLE STORAGE BLD	20APR82	7	0.317	0.322	0.350
249	NAD	AC VENT BLDG	20APR82	16	..269	0.298	0.310
250	NAD	INSTALL EXT LGHTNG	22APR82	13	0.271	0.124	0.260
251	NAD	HEATED RNG CLASSRM	29APR82	15	0.292	0.149	0.422
252	NAD	FIRING RANGE MOD	06MAY82	6	0.109	0.089	0.134
253	EUR	READY BLDG	13MAY82	5	0.215	0.197	0.464
254	NAD	PERIMETER SCTY FNC	26MAY82	7	0.265	0.221	0.243
255	NAD	CSH STG & MNT FAC	27MAY82	6	0.447	0.469	0.487
256	NAD	COURTS & FIELDS	01JUN82	2	0.304	0.243	0.420
257	NAD	SAB TERM ADDN	03JUN82	13	0.342	0.250	0.435
258	MRD	CO ADMIN & SUPP	07JUN82	7	0.392	0.302	0.450
259	NAD	TACT EQUIP SHOPS	07JUN82	6	0.399	0.336	0.330
260	SWD	ALTER BLDG 421	10JUN82	8	0.202	0.214	0.251
261	NAD	AMMO SURV BLDG	15JUN82	15	0.270	0.222	0.283
262	SPD	TR VEH ROUGH WASHER	08DEC81	22	0.448	0.336	0.460
263	SPD	RANGE CONTROL BLDG	29DEC81	10	0.199	0.184	0.220
264	SWD	FIRE TRNG CLASSROOM	05JAN82	8	0.467	0.361	0.485
265	SWD	LASER ENGAGEMENT WH	05JAN82	8	0.498	0.355	0.473
266	OHR	SLUDGE DRYING FAC	06JAN82	13	0.368	0.242	0.340
267	SAD	NIGHT FIRE RANGE	06JAN82	9	0.251	0.131	0.227
268	NAD	ALT TO 4 BLDG	12JAN82	6	0.223	0.170	0.152
269	OHR	FIRE SAFETY IMPR	12JAN82	11	0.222	0.110	0.189
270	OHR	OMNI DIR APP LTG SY	19JAN82	13	0.092	0.087	0.103
271	SPD	EXT FNCNG UTIL PAV	28JAN82	13	0.336	0.286	0.371
272	SPD	MBD FAC UPGD	26JAN82	16	0.383	0.314	0.400
273	SWD	BOILER CONTROL	03FEB82	13	0.193	0.092	0.290
274	NAD	OSHA DEFIENCIES	03FEB82	4	0.127	0.124	0.220
275	NAD	EVAL COOLING	[illegible]	[illegible]	[illegible]	0.142	0.200
276	NPD	PHYSICAL SECURITY	09FEB82	3	0.249	0.199	0.368
277	EUR	EUD OFC ANNEX	10FEB82	14	0.410	0.378	0.499
278	NAD	BLDG 814 TO DENTAL	17FEB82	14	0.444	0.277	0.477
279	MRD	MOD DINING FAC	16JUN82	6	0.298	0.354	0.360
280	EUR	PATRIOT FAC	16JUN82	9	0.330	0.267	0.471
281	NAD	SEWAGE PUMPING FAC	17JUN82	4	0.140	0.121	0.125
282	NPD	RANGE BN INF HQ	22JUN82	12	0.113	0.104	0.133
283	NAD	IMPR SEWAGE TRMT PL	24JUN82	9	0.340	0.188	0.302
284	EUR	INSTALL LOOP LINE	22JUN82	3	0.132	0.120	0.222
285	OHR	HQ MEPCOM ALT	29JUN82	4	0.451	0.309	0.195
286	EUR	V CORPS BATTLE CTR	08JUL82	5	0.369	0.366	0.412
287	EUR	HEAVY DROP RIG FAC	14JUL82	5	0.257	0.202	0.432
288	NPD	VOLTAGE REGULATOR	15JUL82	2	0.192	0.173	0.130
289	SWD	ADDN HEALTH CLINIC	20JUL82	5	0.403	0.388	0.456
290	SWD	TARGET LAUNCH CAMP	27JUL82	10	0.407	0.380	0.480
291	NAD	ALTER BLDG 59	29JUL82	7	0.140	0.091	0.212
292	EUR	SECURITY FENCE	03AUG82	2	0.182	0.203	0.353
293	NPD	RELOC YUCON RFL RNG	06AUG82	5	0.447	0.422	0.426
294	NAD	ADD/ALT BLDG 665	06AUG82	9	0.133	0.120	0.188

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC		DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMT
197	EUR	INSTRUCTIONAL BLDG	16FEB82	12	0.339	0.355	0.415
198	NAD	GUIDED MSL MAINT	23FEB82	24	8.588	5.487	9.250
199	SAD	HOSPITAL ADD/ALT	25FEB82	6	20.220	17.117	27.590
200	SWD	DS/GS MAINT FAC	04MAR82	12	0.698	0.613	0.970
201	EUR	POL POLLUTION CTRL	25MAR82	15	0.775	0.648	0.997
202	SAD	ABERDEEN TNG FAC	13APR82	10	4.819	4.240	6.130
203	SAD	SUPPORT & MAINT	13APR82	10	3.510	3.286	5.188
204	NAD	MOD IND FAC III	20APR82	7	11.096	8.819	10.800
205	EUR	IMP POL HANDLING	20APR82	10	0.726	0.686	1.500
206	EUR	RANGE UPGRADE	20APR82	8	0.961	0.884	1.300
207	EUR	POL POLLUTION CTRL	18MAY82	11	0.607	0.389	0.500
208	SAD	INS, STM WNDW WEATH	29JUN82	16	0.516	0.326	0.676
209	EUR	POL POLLUTION CTRL	08JUN82	13	1.413	1.012	0.752
210	EUR	HOSPITAL PHASEIII	20JUL82	6	5.901	5.611	5.401
211	SAD	ELEC/MECH UPGD HOSP	03AUG82	9	14.850	12.387	16.500
212	EUR	TACT EQUIP SHOP	10AUG82	14	1.650	1.546	2.600
213	EUR	ECIP TEMP HEAT REC	10AUG82	4	1.211	1.140	2.270
214	SAD	UPGRD SEWAGE PLANT	12AUG82	7	0.268	0.270	0.300
215	EUR	AMMO IGLOOS	12AUG82	16	1.379	1.468	1.800
216	EUR	BN HQ & CLASSROOM	13AUG82	18	0.527	0.381	1.050
217	EUR	BARRACKS	17AUG82	13	2.407	2.144	5.550
218	EUR	TEMP HEAT RCVRY	18AUG82	6	1.149	0.874	2.300
219	EUR	AUTO HEATING SYSTEM	24AUG82	13	3.003	2.875	5.500
220	SPD	REC CENTER	25AUG82	13	1.730	1.660	2.250
221	SPD	WATER SUP IMP	26AUG82	10	0.623	0.338	0.397
222	EUR	BKS.WASH/POL POINT	31AUG82	8	0.761	0.639	0.800
223	SAD	ADMIN AREA IMP	03SEP82	11	1.412	1.539	1.800
224	EUR	AUTO HTG SYSTEM	02SEP82	4	3.576	2.062	2.500
225	EUR	IMPR POL-MAINT FAC	07SEP82	10	1.577	1.121	1.360
226	SAD	STORAGE TANK	15SEP82	8	0.443	0.321	0.563
227	EUR	AUTO HEATING SYSTEM	22SEP82	12	0.984	0.728	2.400
228	MRD	EMCS COMPUTER RM	30SEP82	5	0.067	0.066	0.080
229	MRD	BARRACKS MOD	24FEB82	17	0.295	0.215	0.289
230	SPD	TRACKED VEH MAINT	02MAR82	20	0.297	0.277	0.349
231	NAD	CORRECT FIRE CODE	02MAR82	6	0.252	0.223	0.226
232	SWD	OBSERVE FIRE TOWER	03MAR82	8	0.268	0.225	0.286
233	NAD	SHIP TO SHORE WASTE	09MAR82	8	0.257	0.179	0.350
234	SAD	ELECTRONIC MAINT SH	10MAR82	9	0.291	0.320	0.322
235	SWD	CO ADMIN & SUPPLY	18MAR82	10	0.410	0.349	0.430
236	SAD	MSL ELEC & HYDR MN	24MAR82	11	0.413	0.357	0.477
237	NAD	INSTALL EXT SUP PW	24MAR82	5	0.178	0.144	0.207
238	OHR	STEAM PLANT MOD	08APR82	6	0.177	0.122	0.300
239	SAD	TRI-TAC TNG FAC	13APR82	8	0.464	0.377	0.499
240	NPD	RENOV HEALTH CLIN	13APR82	6	0.446	0.405	0.443
241	EUR	MINI GYM	14APR82	14	0.052	0.053	0.118
242	EUR	MINI GYM	14APR82	14	0.066	0.045	0.118
243	EUR	MINIGYM	14APR82	14	0.059	0.052	0.118
244	EUR	MINIGYM	14APR82	14	0.044	0.049	0.118
245	EUR	MINI GYM	15APR82	14	0.129	0.049	0.129

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC		DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMT
148	EUR	CHILD CARE CENTER	23JUL82	10	1.277	0.941	1.407
149	EUR	ADMIN BLDG	27JUL82	8	0.619	0.173	1.150
150	EUR	ECIP	27JUL82	4	0.205	0.203	0.410
151	EUR	ECIP	29JUL82	6	0.197	0.115	0.305
152	EUR	AUTO HEAT PLANT	03AUG82	4	0.228	0.241	0.264
153	EUR	BARRACKS SEWER LINE	03AUG82	7	1.024	0.886	0.455
154	SAD	BOILERS	03AUG82	5	22.500	14.980	19.000
155	NAD	GP MAGAZINES	04AUG82	10	0.689	0.524	0.760
156	EUR	TACT EQUIP SHOP	05AUG82	5	0.165	0.155	1.286
157	EUR	AMMO IGLOOS	05AUG82	5	0.156	0.129	0.280
158	EUR	AMMO IGLOOS	05AUG82	3	0.142	0.061	0.154
159	EUR	AMMO IGLOOS	02SEP82	14	0.176	0.123	0.265
160	EUR	BARRACKS W/ DINING	05AUG82	5	7.092	7.008	13.668
161	SWD	HOSPITAL PHASE II	05AUG82	13	66.285	59.787	81.000
162	EUR	MISSLE MNT FAC	10AUG82	15	3.120	2.697	5.500
163	EUR	BARRACKS	10AUG82	16	2.092	2.003	4.800
164	NAD	BARRACKS MOD	11AUG82	7	13.492	8.889	18.600
165	EUR	TACT EQUIP SHOP	12AUG82	10	2.679	2.392	3.940
166	EUR	HARDSTAND TACT FAC	12AUG82	11	0.475	0.370	0.800
167	EUR	AMMO SURV BLDG	13AUG82	11	0.736	0.694	0.965
168	EUR	BARRACKS MLRS	17AUG82	10	1.377	1.253	3.485
169	EUR	TACT EQUIP SHOP	17AUG82	6	1.786	1.433	2.050
170	SPD	INSULATION	18AUG82	8	0.502	0.302	0.520
171	EUR	UTILITIES SUP-MLRS	18AUG82	49	8.070	6.351	7.400
172	EUR	UTILITIES-PX CMMSRY	18AUG82	8	2.641	2.399	2.573
173	SWD	CHILD CARE CENTER	19AUG82	5	2.141	2.055	2.050
174	EUR	MIS & TAC EQUIP SHP	19AUG82	14	4.031	3.451	5.100
175	SAD	RECEPT & PROCESS CN	24AUG82	7	3.023	2.649	3.800
176	EUR	RELOC BARRACKS	25AUG82	6	0.967	0.860	1.175
177	EUR	BEQ	25AUG82	7	1.535	1.370	2.340
178	EUR	AMMO IGLOOS	25AUG82	9	0.634	0.568	0.965
179	EUR	MAINT HARDSTAND	26AUG82	14	5.058	4.013	7.100
180	SWD	TRAINING FAC-ROLAND	27AUG82	6	3.020	2.523	3.700
181	EUR	FAC MOD II	27AUG82	4	3.579	3.008	5.226
182	NAD	WINDOW TRMT INSUL	01SEP82	6	3.345	2.343	3.600
183	SAD	ADMIN AREA IMP	02SEP82	11	1.412	1.537	1.850
184	SWD	OSHA DEFICIENCIES	03SEP82	7	0.670	0.741	0.770
185	EUR	HEATING PLANT-BEQ	07SEP82	6	1.054	1.173	1.266
186	MRD	INCINERATOR PLANT	08SEP82	12	3.515	3.035	3.750
187	SAD	EXP TRUCK ACESSROAD	10SEP82	6	0.627	0.450	0.880
188	SAD	BRIGADE MAINT FAC	13SEP82	11	2.694	2.063	2.929
189	EUR	AMMO IGLOOS	14SEP82	6	0.920	0.973	0.884
190	EUR	VEH MAINT BLDG	07OCT81	12	0.850	0.831	0.960
191	NAD	CHEM SEC UPGRADE	07OCT81	2	0.348	0.234	0.375
192	SPD	LIQUID WASTE DISP	16OCT81	10	2.215	1.341	1.800
193	SAD	CONDENSATE RET LN	21OCT81	12	0.864	0.711	1.450
194	SWD	BATTERY REPAIR-OSHA	21OCT81	4	0.527	0.534	0.609
195	MRD	INSULATE BLDG	01DEC81	12	0.998	0.986	1.550
196	NPD	PERSHING II	02FEB82	12	1.850	1.529	3.900

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC		DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAM
99	EUR	AMMO STORAGE	18MAY82	8	0.169	0.153	0.245
100	EUR	IGLOO STORAGE	18MAY82	8	0.039	0.028	0.055
101	EUR	IGLOO STORAGE	18MAY82	8	0.045	0.033	0.068
102	EUR	IGLOO STORAGE	18MAY82	8	0.056	0.042	0.082
103	EUR	IGLOO STORAGE	18MAY82	8	0.117	0.039	0.049
104	NAD	UTILITIES EXPANSION	25MAY82	8	4.533	2.427	3.550
105	NAD	GEN INST BLDG	27MAY82	11	2.487	1.989	3.250
106	OHR	ALTER HQ FAC-PK II	27MAY82	10	2.747	2.467	4.000
107	EUR	IGLOO STORAGE	01JUN82	3	0.041	0.007	0.008
108	EUR	TACT EQUIP SHOP	01JUN82	6	0.732	0.531	1.809
109	EUR	BARRACKS MODERN	02JUN82	16	1.691	1.347	1.568
110	EUR	BARRACKS	02JUN82	8	3.132	2.511	5.708
111	EUR	IGLOO STORAGE	02JUN82	3	0.068	0.080	0.055
112	NAD	R&D BLDG MOD	03JUN82	6	25.299	16.010	26.000
113	EUR	FACILITIES MODERN	03JUN82	11	5.396	3.994	6.432
114	SAD	STEAM LINE INC	03JUN82	19	3.019	1.368	4.750
115	NAD	BN HQ AND CLASSROOM	08JUN82	8	1.178	0.843	1.300
116	EUR	ALT HOSPITAL	08JUN82	7	10.687	7.828	26.532
117	EUR	ECIP HEAT PLANT	08JUN82	12	0.525	0.395	0.630
118	SAD	TRAINEE BARRACKS	10JUN82	15	14.225	13.304	19.850
119	EUR	PAVE ROADS	15JUN82	21	0.401	0.249	0.635
120	SWD	BARRACKS COMPLEX 2	16JUN82	7	0.633	0.453	0.633
121	SWD	EMCS	17JUN82	8	0.745	0.820	0.840
122	NAD	REFUSE FIRED INCIN	17JUN82	10	2.170	2.146	2.150
123	EUR	TEMP HEAT RECOVERY	22JUN82	10	1.467	1.261	2.500
124	NAD	PHYSICAL FITNESS	22JUN82	7	3.882	2.864	5.200
125	EUR	CHAPEL/REL ED CTR	30JUN82	11	1.925	1.462	2.050
126	EUR	BASIC LOAD SITE	30JUN82	5	1.598	1.513	2.090
127	EUR	TACT EQUIP SHOP	06JUL82	12	0.638	0.545	1.166
128	SAD	OSHA DEFICIENCIES	08JUL82	14	0.47[illegible]	0.447	0.700
129	SAD	MISC PLO ABATMENT	13JUL82	7	0.917	0.744	0.790
130	EUR	AMMO IGLOO	13JUL82	5	0.149	0.166	0.210
131	EUR	HEAVY EQUIP MNT FAC	13JUL82	8	5.042	4.296	5.754
132	NAD	EMCS	14JUL82	11	1.400	1.148	2.800
133	NAD	HEAT RECOVERY	15JUL82	13	5.398	5.387	4.100
134	EUR	FACS MOD, SEWER UGD	16JUL82	10	1.927	2.033	2.806
135	EUR	BKS W/ DINING	16JUL82	10	2.772	1.586	6.550
136	EUR	ADMIN BLDG	16JUL82	10	1.417	0.434	3.150
137	EUR	SUPPLY OFC AND WHSE	16JUL82	10	0.839	0.213	1.300
138	EUR	CMMTY ACT FAC	16JUL82	10	0.320	0.088	0.590
139	EUR	BARRACKS FACS	16JUL82	8	1.898	1.110	2.900
140	EUR	COMMTY ACTS FAC	20JUL82	8	0.384	0.147	0.650
141	EUR	BARRACKS	20JUL82	8	1.888	1.061	2.500
142	EUR	ADMIN BLDG	20JUL82	8	0.519	0.135	1.050
143	EUR	CMMTY BLDG	20JUL82	8	0.496	0.172	0.960
144	EUR	FLT SIM BLDG	20JUL82	7	4.892	3.281	8.000
145	NAD	WINDOW TRMT INSUL	20JUL82	12	0.510	0.369	0.620
146	EUR	ECIP	22JUL82	5	0.582	0.453	0.699
147	SWD	BARRACKS	26JUL82	7	2.800	2.640	3.142

TABLE A.1 - ORIGINAL DATA
(Continued)

	LOC	DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMI
50	EUR	RANGE UPGRD IFV	04MAR82	18	0.091	0.086	0.241
51	SPD	UPGRADE PWR LINE	04MAR82	19	0.586	0.496	1.500
52	EUR	MAJOR TNG AREA UPGD	04MAR82	18	0.175	0.216	0.400
53	EUR	BARRACKS-SOTAS	04MAR82	20	1.067	0.934	2.211
54	SPD	CO ADMIN AND SUPPLY	11MAR82	11	2.166	1.238	2.400
55	SWD	ADV PWR TNG TEST FC	11MAR82	5	2.203	2.495	2.350
56	SPD	EMERGENCY GENERATOR	16MAR82	13	1.012	1.094	0.810
57	SAD	INCIN W/HEAT RECVRY	16MAR82	17	3.347	2.673	3.700
58	EUR	FAC MODERN MAINT FC	18MAR82	13	2.929	2.178	4.800
59	SPD	BARRACKS	18MAR82	14	7.788	7.257	9.000
60	SPD	CO ADMIN AND SUPPLY	18MAR82	14	3.223	2.875	3.600
61	SPD	BN HQ AND CLASSROOM	18MAR82	14	2.417	2.293	2.600
62	NAD	MED ADMIN AND SPT	23MAR82	12	5.856	3.056	6.250
63	SPD	DINING FAC	24MAR82	8	2.956	3.691	3.850
64	SAD	BN HQ AND CLASSROOM	25MAR82	14	0.901	0.825	1.200
65	POD	AMMO STORAGE	31MAR82	5	1.826	2.065	1.950
66	EUR	TANK MAINT FAC	23MAR82	14	3.551	3.311	5.869
67	EUR	AMMO STRG-MLRS	30MAR82	12	0.401	0.290	0.501
68	POD	DENTAL CLINIC	30MAR82	10	2.988	2.877	3.800
69	EUR	IGLOO STORAGE	30MAR82	7	0.063	0.063	0.080
70	NAD	IMPRVE UTIL SYS	01APR82	13	2.809	1.575	3.100
71	EUR	TACT EQUIP SHOP	01APR82	9	0.538	0.573	0.925
72	MRD	CORRECT OSHA DEF	07APR82	4	0.772	0.565	0.670
73	EUR	BARRACKS W/ DINING	07APR82	13	6.896	6.893	12.804
74	EUR	IGLOO STORAGE	08APR82	4	.	0.045	0.096
75	EUR	IGLOO STORAGE	08APR82	4	0.059	0.032	0.068
76	EUR	IGLOO STORAGE	08APR82	4	0.061	0.035	0.068
77	NAD	BARRACKS MODERN	13APR82	22	1.354	1.060	1.450
78	OHR	CONTAM WASTE PROCES	14APR82	7	0.603	0.517	1.450
79	NPD	PHYSICAL FITNESS CN	20APR82	8	5.815	4.462	6.700
80	EUR	RANGE UPGRADE	20APR82	8	0.961	0.884	1.300
81	SAD	CONV BLDG C1 LAB	21APR82	12	2.863	2.177	2.600
82	SPD	CONTAM WASTE PROCES	22APR82	13	0.493	0.404	1.500
83	EUR	IGLOO STORAGE	23APR82	8	0.042	0.040	0.055
84	EUR	IGLOO STORAGE	24APR82	7	0.050	0.034	0.055
85	NAD	TACT EQUIP SHOP	27APR82	10	4.474	2.968	5.100
86	SPD	SECURITY IMPRVRMNT	28APR82	4	0.530	0.369	1.150
87	NAD	OSHA DEFICIECCIES	28APR82	6	0.305	0.317	0.820
88	EUR	AMMO IGLOOS	11MAY82	9	0.169	0.143	0.245
89	NAD	WINDOW TRMT INSUL	18MAY82	11	2.671	3.069	3.550
90	EUR	TACT EQUIP SHOP	18MAY82	10	1.942	1.818	4.520
91	EUR	IGLOO STORAGE	18MAY82	8	0.053	0.032	0.058
92	EUR	IGLOO STORAGE	18MAY82	8	0.042	0.029	0.047
93	EUR	IGLOO STORAGE	18MAY82	10	0.042	0.031	0.053
94	EUR	IGLOO STORAGE	18MAY82	8	0.058	0.043	0.082
95	EUR	IGLOO STORAGE	18MAY82	8	0.094	0.071	0.123
96	EUR	IGLOO STORAGE	18MAY82	8	0.051	0.039	0.082
97	EUR	IGLOO STORAGE	18MAY82	8	0.055	0.041	0.068
98	EUR	IGLOO STORAGE	18MAY82	8	0.043	0.031	0.055

TABLE A.1 - ORIGINAL DATA

	LOC	DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMT
1	EUR	FORKLIFT CHARGING	17NOV81	4	0.543	0.534	0.501
2	EUR	TACTICAL EQUIPMT SH	17NOV81	8	1.937	1.313	1.970
3	NAD	SPRINKLER SYS OSHA	24NOV81	3	0.472	0.484	0.510
4	EUR	BARRACKS	24NOV81	23	1.523	1.104	2.332
5	EUR	STINGER TGT SIMUL	24NOV81	11	0.611	0.551	1.126
6	EUR	BARRACKS	24NOV81	23	.	3.972	8.522
7	NAD	LANDHILL CLOSURE	25NOV81	12	1.671	0.821	1.800
8	NAD	ADV HK ENER LAUNCH	25NOV81	20	2.135	1.5[illegible]3	2.800
9	EUR	BATTALION HQ	01DEC81	16	1.261	0.890	1.688
10	EUR	BARRACKS	02DEC81	18	2.787	2.056	4.824
11	EUR	STINGER TGT SIMUL	04DEC81	9	0.551	0.454	1.126
12	EUR	TACTICAL EQUIP SHOP	09DEC81	13	2.266	1.712	3.940
13	EUR	HELIPADS	14DEC81	27	0.759	0.304	0.711
14	SAD	WASHRACK UPGRADE	16DEC81	16	0.584	0.435	0.760
15	SAD	AMMO SUPPLY POINT	16DEC81	30	7.753	5.356	11.600
16	NAD	SURVEILLANCE WKSHP	17DEC81	13	1.921	1.438	2.200
17	SAD	FIRE STATION	17DEC81	2	.	0.868	1.350
18	EUR	OPER BLDG	18DEC81	20	0.828	0.720	1.566
19	SPD	TACTICAL EQUIP SHOP	14JAN82	18	.	3.867	11.600
20	SPD	SUPPORT MAINT FAC	14JAN82	18	.	4.176	6.300
21	SPD	GEN SPT MAINT FAC	14JAN82	18	.	6.808	7.000
22	NPD	VEH EXHAUST SYS	21JAN82	7	1.557	1.111	1.200
23	SWD	BN HQ AND CLASSROOM	21JAN82	10	1.985	1.874	2.200
24	SWD	CO ADMIN AND SUPPLY	21JAN82	10	3.161	2.757	3.900
25	NPD	VEH EXHAUST SYS	21JAN82	7	1.296	0.864	1.150
26	SWD	DIV SUP-SI FAC	26JAN82	8	0.497	0.386	0.630
27	NAD	WINDOW TRMT INSUL	27JAN82	7	2.095	2.176	2.750
28	SWD	TACT EQUIP SHOP	02FEB82	15	5.438	4.350	8.000
29	NAD	ENERGY IMPROVEMENT	02FEB82	8	1.165	1.172	1.500
30	SAD	WASTE PROCESS INCIN	03FEB82	8	0.959	0.898	0.959
31	SAD	NON-DIV MAINT FAC	03FEB82	9	0.245	0.168	1.100
32	EUR	MAINT FAC	09FEB82	8	1.834	1.578	3.136
33	SPD	ELECT TGT MAINT FAC	09FEB82	10	0.594	0.489	0.600
34	EUR	BARRACKS MODERNIZA	09FEB82	9	0.683	0.569	1.246
35	EUR	FACILITIES MOD	15FEB82	23	2.415	2.151	4.663
36	NAD	GUID MSL MYN FAC AD	23FEB82	24	8.588	5.487	9.250
37	SWD	TACT EQUIP SHOP	23FEB82	11	0.519	0.452	0.660
38	SWD	TACT EQUIP SHOP	23FEB82	7	3.820	3.215	4.250
39	NAD	OSHA DEFICIENCIES	25FEB82	19	0.409	0.214	0.640
40	EUR	BKS W/ ADMIN	25FEB82	26	1.121	0.853	2.090
41	NAD	UPGRADE A/C	25FEB82	13	1.469	0.860	1.600
42	EUR	SCHAEBISCH HALL	02MAR82	5	0.429	0.336	0.881
43	OHR	GYM W/ 50 MTR POOL	02MAR82	6	3.900	2.547	3.900
44	EUR	IGLOO STORAGE	02MAR82	4	0.036	0.042	0.053
45	NAD	EMCS	03MAR82	6	0.535	0.259	1.200
46	SAD	BARRACKS	04MAR82	8	6.054	5.884	9.000
47	OHR	CIDC FIELD OPS BLDG	04MAR82	15	1.194	0.893	1.500
48	EUR	XM1 RANGE 4,10,20	04MAR82	18	1.223	1.348	2.000
49	SAD	CO ADMIN AND SUPPLY	04MAR82	8	1.340	1.413	0.950

TABLE A.1 - ORIGINAL DATA
(Continued)

LOC		DESCRIP	DATE	NUM BID	GOV- EST	LOW- BID	PRO- GAMT
687	EUR	PHYS FITNESS CTR	21FEB84	10	0.156	0.145	0.410
688	EUR	MAINT HANGAR ADD	22FEB84	8	0.489	0.418	1.200
689	SWD	MULTI-PURP TRNG RNG	23FEB84	6	8.501	5.790	9.600
690	MRD	CO ADMIN & SUPPLY	23FEB84	10	1.412	1.101	1.700
691	MRD	CO ADMIN & SUPPLY	23FEB84	10	1.725	1.354	2.150
692	MRD	CO ADMIN & SUPPLY	23FEB84	10	1.412	1.122	1.500
693	MRD	BRIGADE HQ	23FEB84	10	1.098	0.865	1.400
694	MRD	BN HQ & CLASSROOM	23FEB84	10	1.098	0.890	1.200
695	MRD	BN HQ & CLASSROOM	23FEB84	10	1.098	0.897	1.200
696	MRD	MAINT HANGAR W/OPS	29FEB84	11	7.745	5.776	8.100
697	EUR	FIRE PROTECTION SYS	29FEB84	4	2.054	1.325	2.550
698	SPD	WATER WELLS	08MAR84	13	5.769	3.490	3.200
699	EUR	BARRACKS-CEWI	08MAR84	8	1.890	1.807	3.100
700	POD	MULTI-PPOSE REC CN	15MAR84	6	2.642	2.192	2.500
701	POD	MISSLE ASSY FAC	15MAR84	6	0.640	0.489	0.830
702	POD	EXPLOSIVE STGE FAC	15MAR84	6	0.573	0.494	0.710
703	POD	PHOTO LAB WASTE WTR	15MAR84	6	0.216	0.205	0.530
704	POD	TACT EQUIP SHOP	15MAR84	11	1.529	1.478	2.200
705	SAD	DINING FAC MOD	19MAR84	5	0.898	0.894	0.700
706	MRD	SEWAGE TRMT PLNT	21MAR84	5	0.416	0.424	0.490
707	POD	BARRACKS W/DINING	21MAR84	14	12.903	11.997	16.400
708	EUR	TACT EQUIP SHOP	22MAR84	10	1.443	1.288	1.700
709	MRD	MAINT COMLPEX PH2	27MAR84	8	9.378	9.117	12.600
710	SWD	MAINT HANGAR/CEWI	28MAR84	12	9.987	8.645	13.200
711	NAD	CSM MEDICAL RSCRCH	29MAR84	13	3.243	2.918	3.650
712	SAD	MG GUN TRNG RNGE	29MAR84	8	1.151	0.747	0.440
713	EUR	FAC MOD SHOP	30MAR84	14	1.526	1.241	2.200
714	EUR	COAL STG RUNOFF	05APR84	11	0.851	0.516	0.550
715	SAD	ELEC DIST SYS	09APR84	6	0.898	0.880	0.760
716	MRD	RANGE ROADS	01MAY84	8	6.583	4.590	7.200
717	SPD	PHYS FITNESS CTR	01MAY84	11	2.056	1.747	3.400
718	MRD	MUTI-PPOSE TRNG RG	02MAY84	7	15.184	12.173	31.000
719	SAD	BARRACKS	03MAY84	8	6.969	7.162	12.000
720	MRD	TACT EQUIP SHOP	09MAY84	7	4.691	4.504	5.000
721	OHR	UPGRADE WATER SUPP	10MAY84	14	2.223	1.913	2.850
722	SWD	MULTI-PPOSE TRNG RG	24MAY84	7	2.778	2.518	2.800
723	SWD	MULTI-PPOSE TRNG RG	24MAY84	7	3.427	3.616	5.200
724	SPD	OUTDOOR COURTS & FD	05JUN84	3	1.227	0.815	1.000
725	SAD	WPNS MAINT TRNG FAC	12JUN84	10	5.331	3.960	5.700
726	SAD	CHEM AGENT DISP FAC	14JUN84	6	7.856	5.938	10.200
727	SWD	DINING FAC MOD	19JUN84	7	4.105	3.500	4.350
728	SAD	ATC EQUIP SHOP	21JUN84	6	4.527	3.549	6.300
729	OHR	TANK INST FAC-M1	21JUN84	12	3.516	2.660	4.200
730	OUR	ENERGY MONITOR CTRL	25JUN84	10	2.218	1.161	3.600
731	SAD	EDUCATION CTR	27MAR84	11	3.914	3.463	5.200
732	SWD	TRAINEE BARRACKS	05APR84	12	21.919	17.091	23.000
733	MRD	ELEC SUBSTATION	18APR84	9	1.066	0.660	1.400
734	SPD	BRIGADE HQ	25APR84	11	0.938	0.786	1.500
735	SWD	VEHICLE/TEAM CBT RG	24MAY84	7	2.524	2.663	3.350

TABLE A.1 - ORIGINAL DATA
(Continued)

	LOC	DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAMT
736	NAD	PHYS FITNESS CTR	05JUN84	5	1.545	1.607	1.500
737	OHB	RENOV BRIDGE	14JUN84	6	3.000	2.527	4.500
738	NAD	ALTER BLDG 61	22SEP83	12	0.804	0.469	0.532
739	EUR	TEST EQUIP PWR SPLY	22SEP83	5	0.145	0.120	0.219
740	NPD	RANGE SUPPORT BLDG	26SEP83	9	0.420	0.397	0.473
741	NPD	MACHINEGUN RANGE	26SEP83	2	0.890	0.872	0.842
742	SPD	AVIATION LAB FAC	28SEP83	2	0.551	0.425	0.460
743	NPD	SOCOM BARRACKS/AD	06OCT83	5	0.445	0.407	0.495
744	NPD	UPGRD HOSPITAL	25OCT83	4	0.475	0.528	0.510
745	EUR	UPGRD ELEC DIST SYS	08NOV83	10	0.235	0.210	0.477
746	SWD	ELEC MAINT SHOP ADD	15NOV83	11	0.209	0.158	0.229
747	EUR	TRNG BLDGS	15NOV83	11	0.436	0.383	0.622
748	SWD	MAINT FAC MG RANGE	16NOV83	8	0.848	0.778	0.946
749	SWD	ADAT ELEC EQUIP BLD	17NOV83	8	0.809	0.556	0.739
750	EUR	READY BLDG	17NOV83	16	0.386	0.290	0.577
751	EUR	SIGNAL INTELL	07DEC83	3	0.297	0.243	0.319
752	EUR	EXT/INT LIGHTING	15DEC83	8	0.195	0.143	0.229
753	MRD	COLD STRG WHSE	28DEC83	5	0.429	0.393	0.549
754	SWD	SENSITIVE INFO FAC	04JAN84	8	0.468	0.388	0.544
755	SAD	AUTOMATED TNG CMD	05JAN84	8	0.241	0.275	0.250
756	SAD	UPGRD ARR/DEP AFLD	17JAN84	2	0.732	0.812	0.806
757	EUR	COAL HTG PLT	24JAN84	9	0.860	0.889	0.996
758	OHR	REHAB APPLIED INST	25JAN84	22	0.884	0.555	0.957
759	EUR	MTR MAINT SHOP	08FEB84	8	0.818	0.691	0.915
760	NAD	EXP MOBIL SPT FAC	14FEB84	8	0.479	0.505	0.547
761	NAD	ACRFT OPT CALIB LAB	16FEB84	14	0.697	0.599	0.587
762	EUR	MCU HOST SUPPLY	28FEB84	8	0.340	0.334	0.422
763	MRD	TRACKED VEH WASHRAC	12MAR84	6	0.520	0.460	0.637
764	SAD	RELOCATE USABN	15MAR84	5	0.908	0.954	0.968
765	SPD	ACADEMIC BLDG	27MAR84	9	0.762	0.658	0.970
766	EUR	MAINT HGR ADDITION	05APR84	7	0.396	0.378	0.702
767	NAD	FIRE PROTCTION SYS	25APR84	6	0.231	0.105	0.470
768	NAD	FIRE STATION	25APR84	4	0.527	0.523	0.643
769	NAD	TMDE CALIB/RPR FAC	26APR84	5	0.383	0.337	0.342
770	EUR	SECURITY FENCE	09MAY84	6	0.186	0.181	0.446
771	SWD	SECURITY PARK/AREA	22MAY84	6	0.298	0.271	0.400
772	SWD	TOXIC CHEM MAINT FA	31MAY84	5	0.474	0.301	0.568
773	SAD	CALIB/REPAIR FAC	05JUN84	6	0.376	0.316	0.269
774	SWD	ITC EXPANSION FAC	13JUN84	3	0.753	0.610	0.738
775	NAD	DAS3 TRNG FAC	26JUN84	4	0.378	0.343	0.294
776	EUR	PATRIOT IRP	22NOV83	6	0.205	0.142	0.288
777	SWD	BINARY MUNITIONS	01DEC83	13	8.008	4.666	7.845
778	SWD	CONTAIN HAZ WASTE	01DEC83	13	2.285	1.330	0.850
779	EUR	EDUCATION FAC	07FEB84	13	0.324	0.307	0.514
780	MRD	CORREC FAC MESS	22FEB84	6	4.289	4.011	5.400
781	EUR	SECURE PARKING	17MAR84	17	1.678	1.393	4.039
782	NAD	INSULATION WTHRSEP	24NOV83	0	0.153	0.146	0.250
783	SAD	WPNS MAINT TRNG FAC	28DEC83	0	0.952	0.966	1.100
784	NAD	WATER WELLS	02FEB84	0	3.485	3.485	3.900

TABLE A.1 - ORIGINAL DATA
(Continued)

	LOC	DESCRIP	DATE	NUM BID	GOV-EST	LOW-BID	PRO-GAM
785	OHR	BN HQ & CLASSROOM	09FEB84	0	1.215	1.215	1.300
786	SAD	INTELLIGENCE TRNG	16FEB84	0	0.959	0.959	1.200
787	NAD	PHYSCIAL FITNESS CN	21FEB84	0	1.578	1.578	1.800
788	OHR	DINING FAC MOD	23FEB84	0	2.127	2.119	2.050
789	SAD	CO ADMIN & SUPPLY	24FEB84	0	0.355	0.345	0.430
790	SWD	REPLACE EXT LGHT	13MAR84	0	0.823	0.711	1.150
791	SPD	UNACC OFFICER QTRS	14MAR84	0	5.900	5.800	5.400
792	NPD	TEMP CONTROLS	14MAR84	0	1.492	1.473	1.450
793	SAD	HARDSTAND	19APR84	0	0.263	0.293	0.370
794	OHR	ENERGY EFFICIENT LT	20APR84	0	0.237	0.229	0.270
795	SAD	CIDC FIELD OPER BLD	26APR84	0	2.060	2.122	2.600
796	SAD	IRETS RANGES	30APR84	0	2.550	2.441	3.500
797	SPD	FIRE STATION	10MAY84	0	0.902	0.831	0.850
798	MRD	BULK FUEL STG FAC	29MAY84	0	2.937	2.925	3.000
799	SWD	PHYSICAL FITNESS CN	31MAY84	0	0.306	0.305	0.310
800	SWD	FIELD LIGHTING ECIP	25JUN84	0	0.644	0.671	0.700
801	POD	COVERED STORAGE	20DEC83	0	0.434	0.341	0.630
802	POD	CO ADMIN SUPPLY	20DEC83	0	0.374	0.339	0.450
803	POD	COMMO/ELECT MAINT	20DEC83	0	0.170	0.152	0.200
804	POD	A/C LIBRARY	26JAN84	0	0.330	0.225	0.620
805	POD	PHYSICAL FITNESS CN	11FEB84	0	0.322	0.269	0.360
806	POD	TACT EQUIP SHOP	16FEB84	0	0.554	0.480	0.610
807	POD	CHAPEL/CMTY CTR	25FEB84	0	0.715	0.614	1.200
808	POD	SECURITY LIGHTING	27FEB84	0	0.313	0.295	0.400
809	POD	CO ADMIN & SUPPLY	27FEB84	0	0.423	0.363	0.470
810	POD	GEN PURP AUDIT	28FEB84	0	0.459	0.435	0.690
811	POD	PHYSICAL FITNESS CN	14MAR84	0	1.212	1.205	1.550
812	POD	TACT EQUIP SHOP	14MAR84	0	4.043	3.407	4.750
813	POD	TECH SUPPLY FAC	19MAR84	0	1.047	0.888	1.650
814	POD	TACT EQUIP SHOP	21MAR84	0	0.392	0.333	1.000
815	POD	PHYSICAL FITNESS CN	25APR84	0	1.517	1.410	1.950
816	POD	GEN PURP AUDIT	25APR84	0	0.312	0.289	0.500
817	POD	WAREHOUSE	05JUN84	0	0.635	0.558	0.750
818	POD	TACT EQUIP SHOP	24JUN84	0	0.703	0.562	0.890
819	POD	DIAG EQUIP FAC	31JAN83	0	0.393	0.334	0.449
820	POD	TEST DIAGN EQUIP	02FEB84	0	0.307	0.271	0.336
821	POD	TEST MEASUREMENT FA	15FEB84	0	0.374	0.333	0.417
822	POD	UPGR HOSP POWER	15FEB84	0	0.742	0.671	0.846
823	POD	TROOP AID STATION	22FEB84	0	0.626	0.495	0.863
824	POD	TROOP AID STATION	22FEB84	0	0.726	0.539	0.905
825	POD	AFKN RELAY TRANS	16MAY84	0	0.361	0.357	0.452
826	EUR	FAC MODERNIZATIION	14JUN84	0	0.250	0.210	0.315
827	NAD	INTER-AMER COLL MOD	18JUN84	0	0.825	0.849	0.769

APPENDIX B

SINUSOIDAL FUNCTION

The sinusoidal function takes the general form:

$$Y = A+(B*SIN(C*X+D)) \qquad (B.1)$$

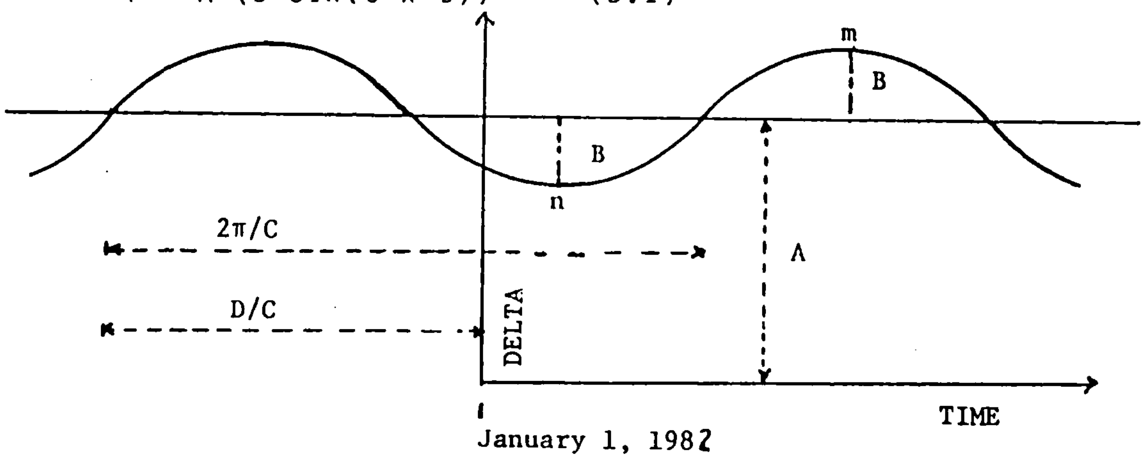


Figure B.1: General Sinusoidal Function

Where:

A = The shift above or below the X-axis.

B = The amplitude of the sinusoidal wave. The maximum variation of the wave function, above or below the mean value.

$2*\pi/C$ = Cycle length of wave. In our case cycle length equals 1 year, so $2*\pi/C=1$ year, therefore, $C=2*\pi$.

D/C = Phase shift of the wave. In our case in time units of years.

A normal sine function has values for the variables:

$$A = 0;$$

$$B = 1;$$

$$C = 1; \text{ and}$$

$$D = 0.$$

This reduces the general sinusoidal function to: Y=SINX, with an amplitude of 1, and a cycle length of 2*π. This function is shown on Figure B-2. The addition of a phase shift of D=π/2 changes the equation to Y=SIN(X+π/2). This causes the function to shift to the left of the origin by π/2 units, as shown on Figure B-3. Similarly, the subtraction of D=π/2 will cause the function to shift to the right by π/2 units, as shown on Figure B-4. Changes in the C parameter will cause the period of the function to increase or decrease. Setting C=2 will half the cycle length. 2*π/C=cycle length with C=2 yields cycle length=;π. This is shown on Figure B-5. Setting C=1/2 will double the cycle length, 2*π/.5=4$\pi$for a cycle length. This is shown on Figure B-6. Changes in the B parameter will cause the amplitude of the function to increase or decrease. Setting B=2, will cause the function to double it's amplitude. This is shown on Figure B-7. Setting B=1/2, will cause the function to half the amplitude of the function. This is shown on Figure B-8.

By varying the three parameters of the sinusoidal function, it is possible to fit the sinusoidal function to the data for seasonal model. In the analysis performed in this thesis, the cycle length was set to one year initially, as previous research indicated that an annual cycle was appropriate to the data. PROC NLIN (Non-Linear model fitting) was used to find estimates for amplitude, B, and phase shift, D/C.

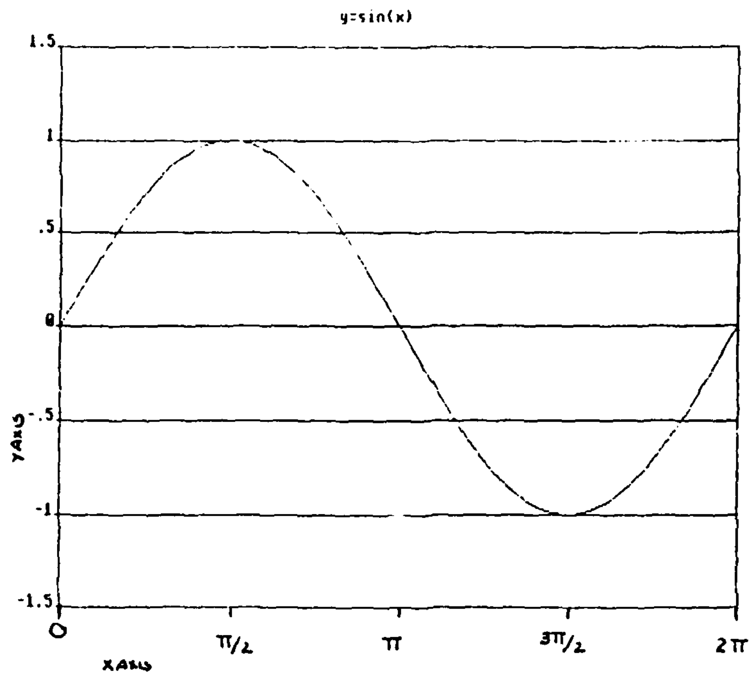


FIGURE B.2: Y=SIN(X)

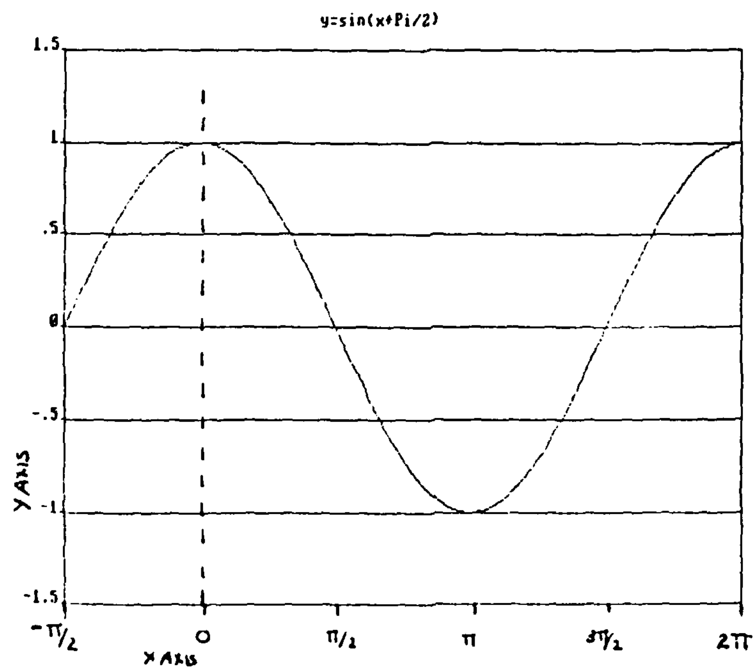


FIGURE B.3: Y=SIN(X+D)

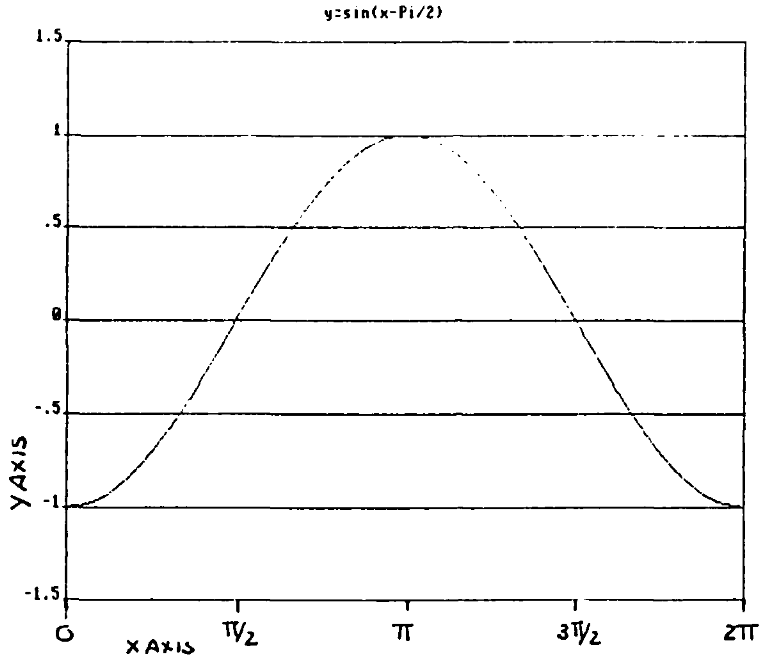


FIGURE B.4: Y=SIN(X-D)

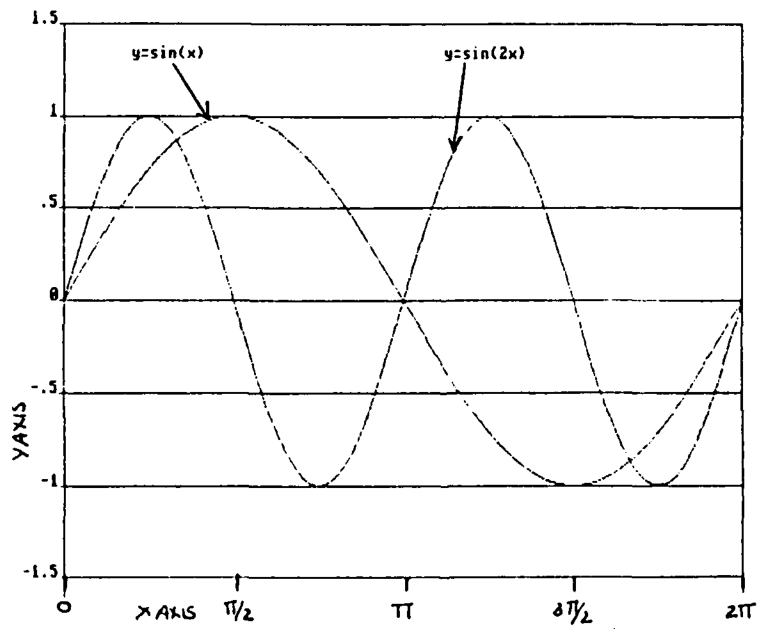


FIGURE B.5: Y=SIN(2*X)

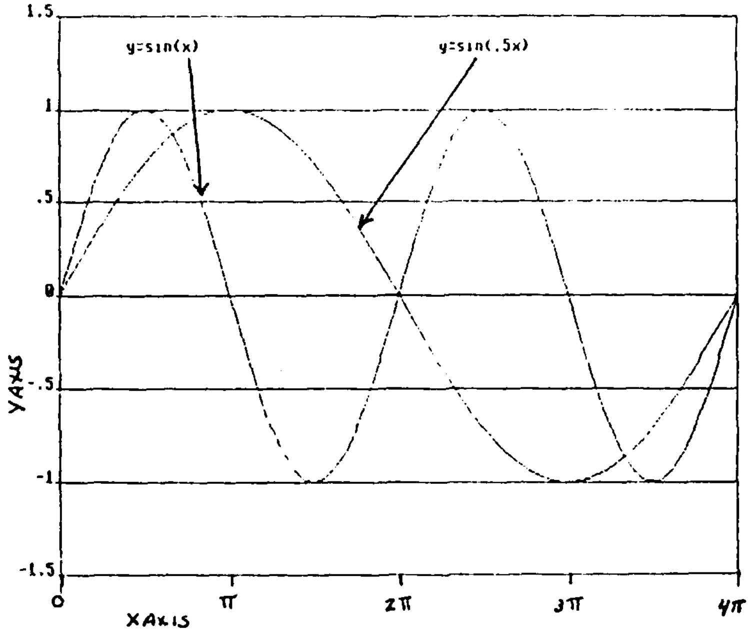


FIGURE B.6: Y=SIN(.5*X)

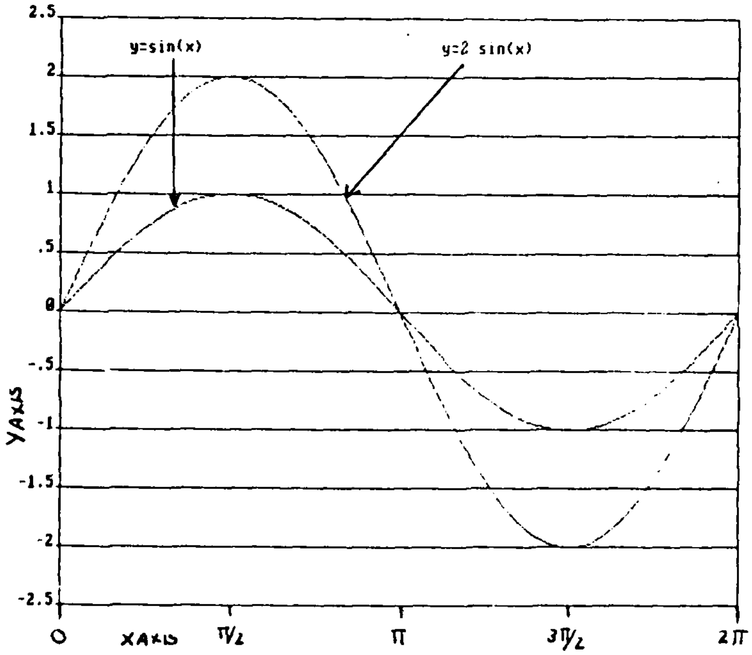


FIGURE B.7: Y=2*SIN(X)

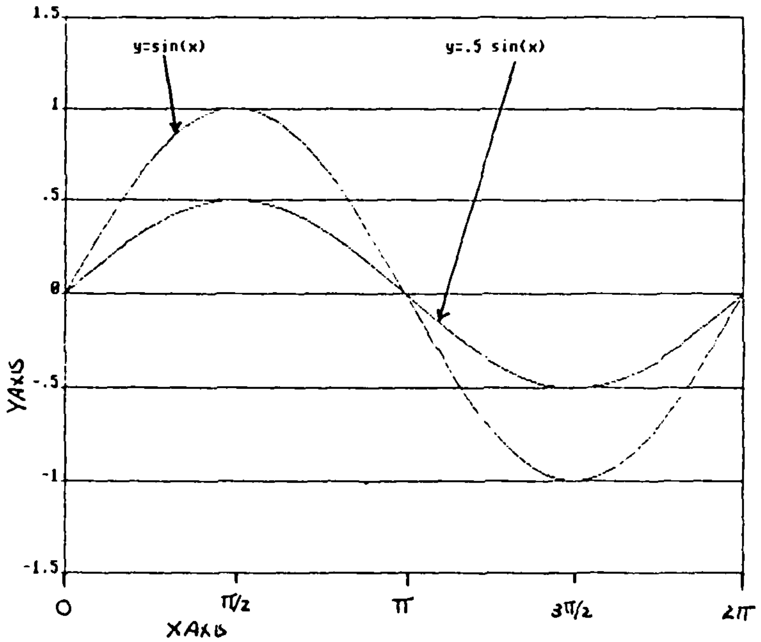


FIGURE B.8: Y=.5*SIN(X)

APPENDIX C

PROGRESSIVE MODEL BUILDING

The method of progressive model building was used in this study. This method involves building a model, obtaining residual error terms from that model, building a model to explain these residuals, obtaining a next set of error terms, and so on until no further models are appropriate in explanation of error. Once a final model is decided upon, all terms are put into one final model, and new values for the parameters are obtained, as well as a final set of residual error terms. This procedure is shown below in equations C.1 to C.3.

```
DELTA = A+(B*X)+RESID1 (linear model)                   (C.1)
RESID1 = C+(D*SIN(TIME))+RESID2 (seasonal model)        (C.2)
RESID2 = E+(F*(X**3))+RESID3 (other appropriate model)(C.3)
```

The final Model with Revised Parameter Estimates is given in equation C.4.

```
DELTA = A1+(B1*X)+(D1*SIN(TIME))+(F1*(X**3))+RESID31  (C.4)
```

APPENDIX D

CUMULATIVE DENSITY FUNCTION

This is a relatively simple method to construct a cumulative distribution for data.

1. Calculate your response variable, in this case DELTA or DELTA1. Sort the variable from lowest value to highest value.
2. Number each observation, I=1, 2, 3.....N.
3. Create the variable PROB=(I-.5)/N.
4. Plot PROB on the Y-Axis and DELTA on the X-Axis.

Figure D.1 was produced by this method. The cumulative distribution is then overlaid the R/S distribution, as shown in Figure D.2. This method is described by Larew in his text (3) and further studied by Ricer (6).

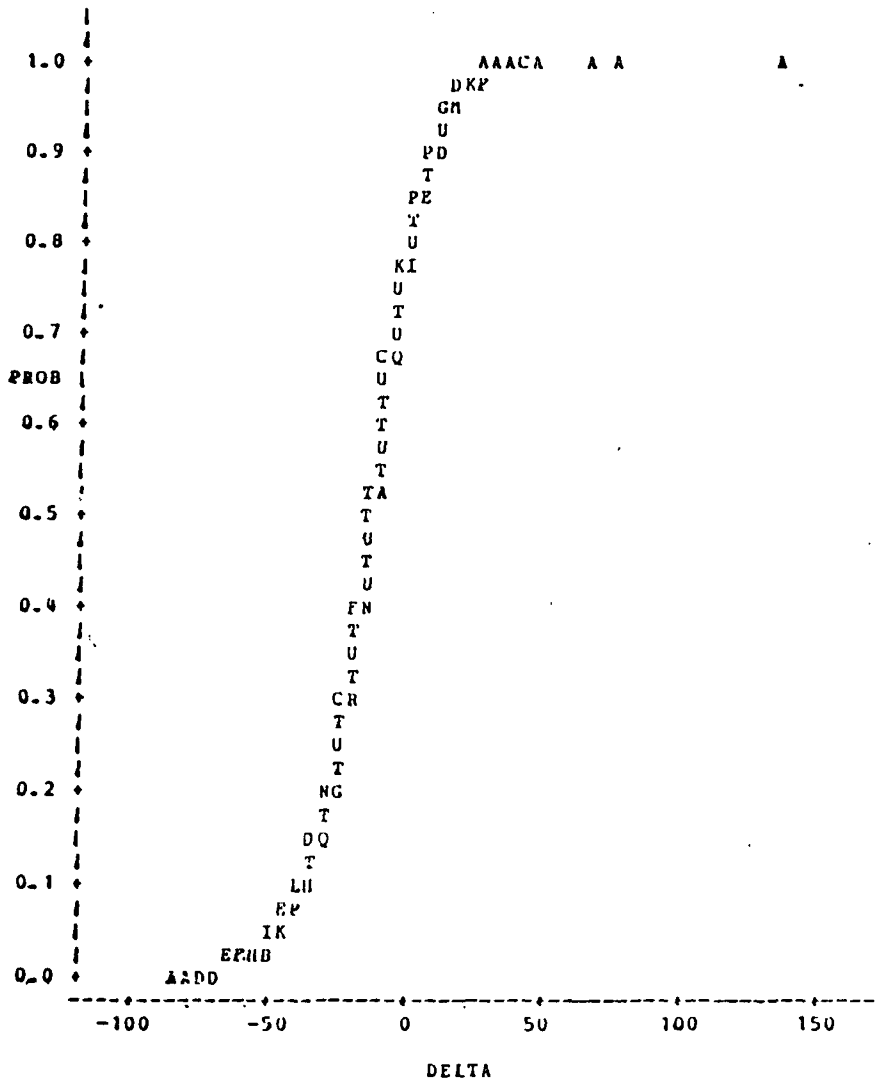


FIGURE D.1: Rank Ordered DELTA vs PROB

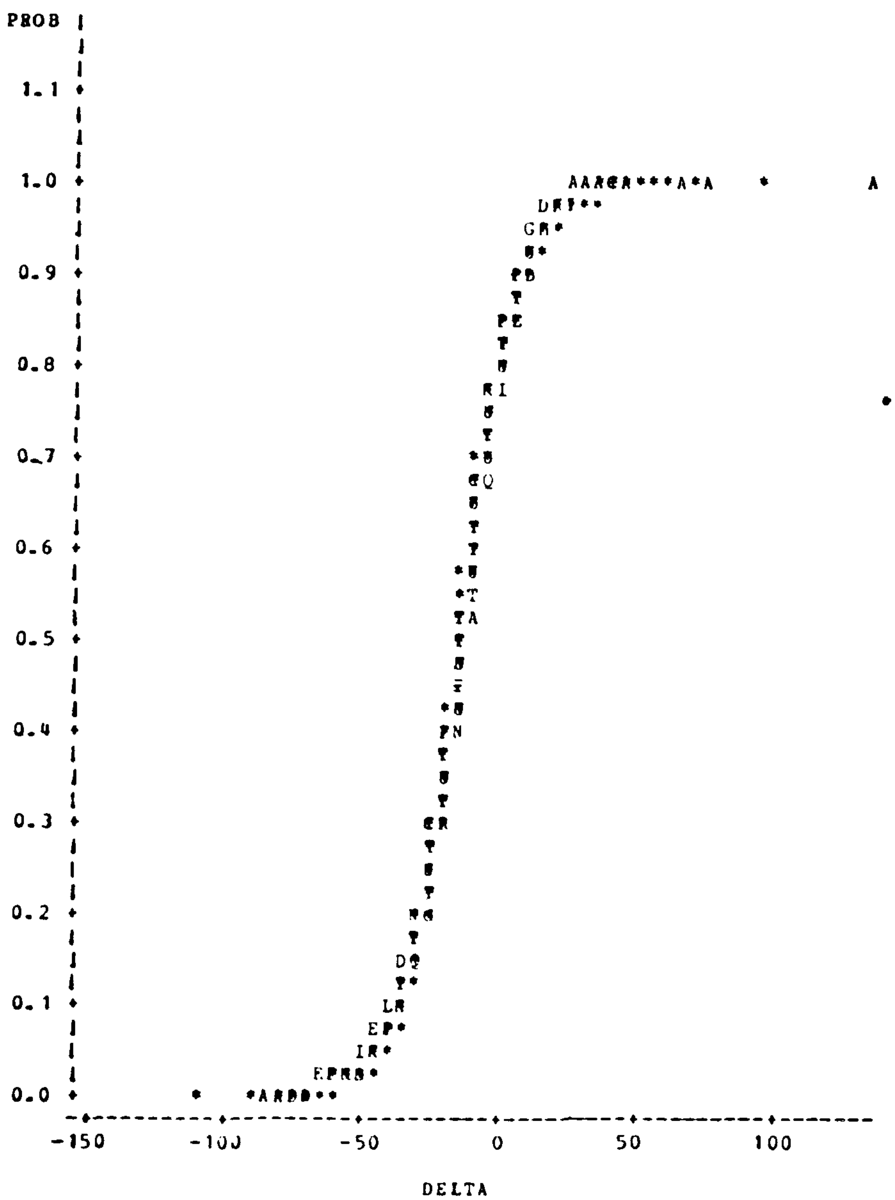


FIGURE D.2: Fitted Curve Overlay on Rank Ordered DELTA

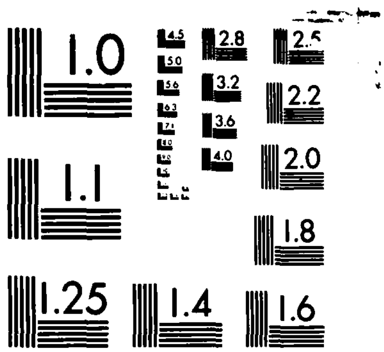
AD-A157 617 AN ANALYSIS OF ESTIMATING ERRORS ON GOVERNMENT CONTRACTS(U) ARMY MILITARY PERSONNEL CENTER ALEXANDRIA VA D L DIEDRICH 22 MAR 85 2/2

UNCLASSIFIED F/G 12/1 NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX E

CDF OF DIVISIONAL MODELS FOR DELTA AND DELTA1

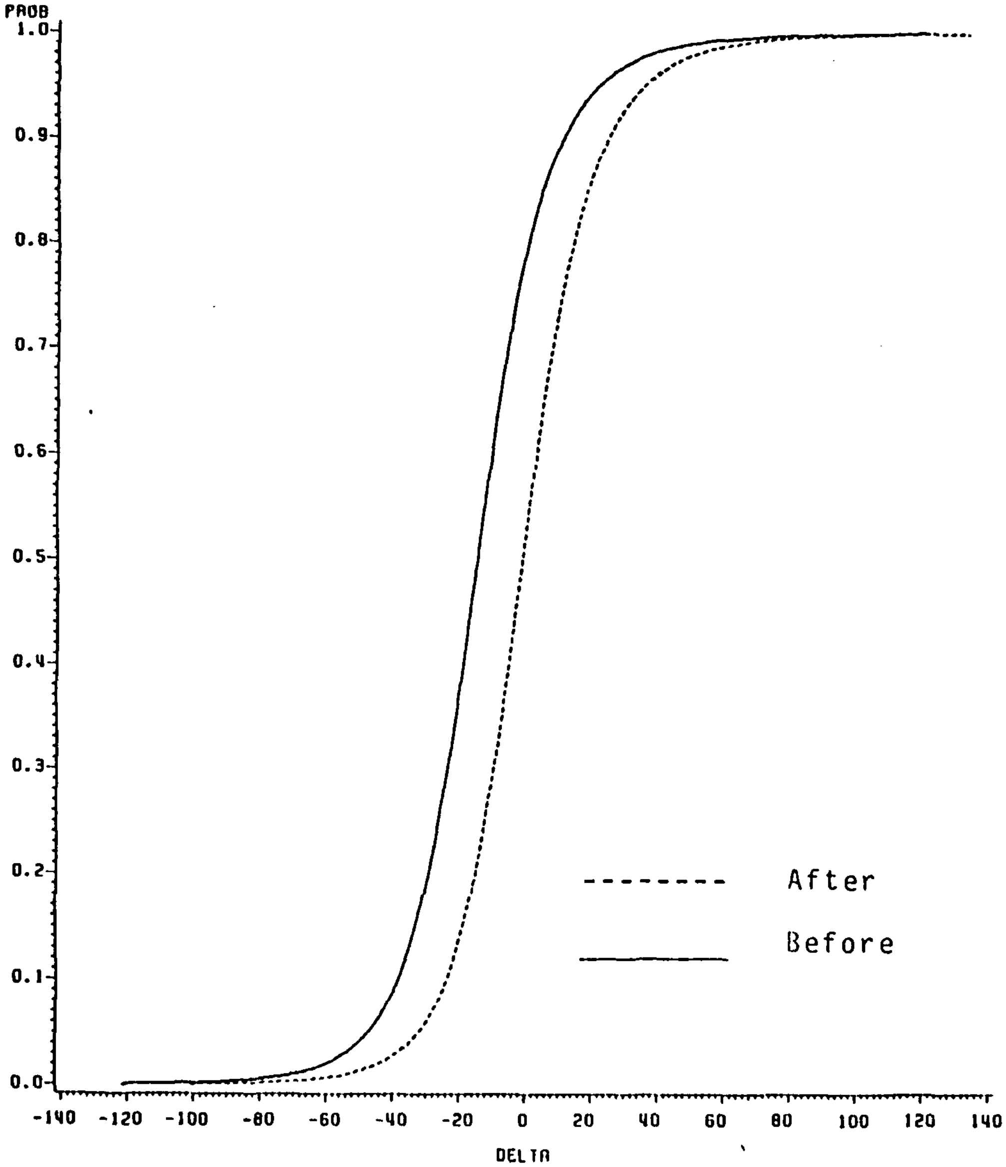


FIGURE E.1: DELTA Before and After Modeling--EUR

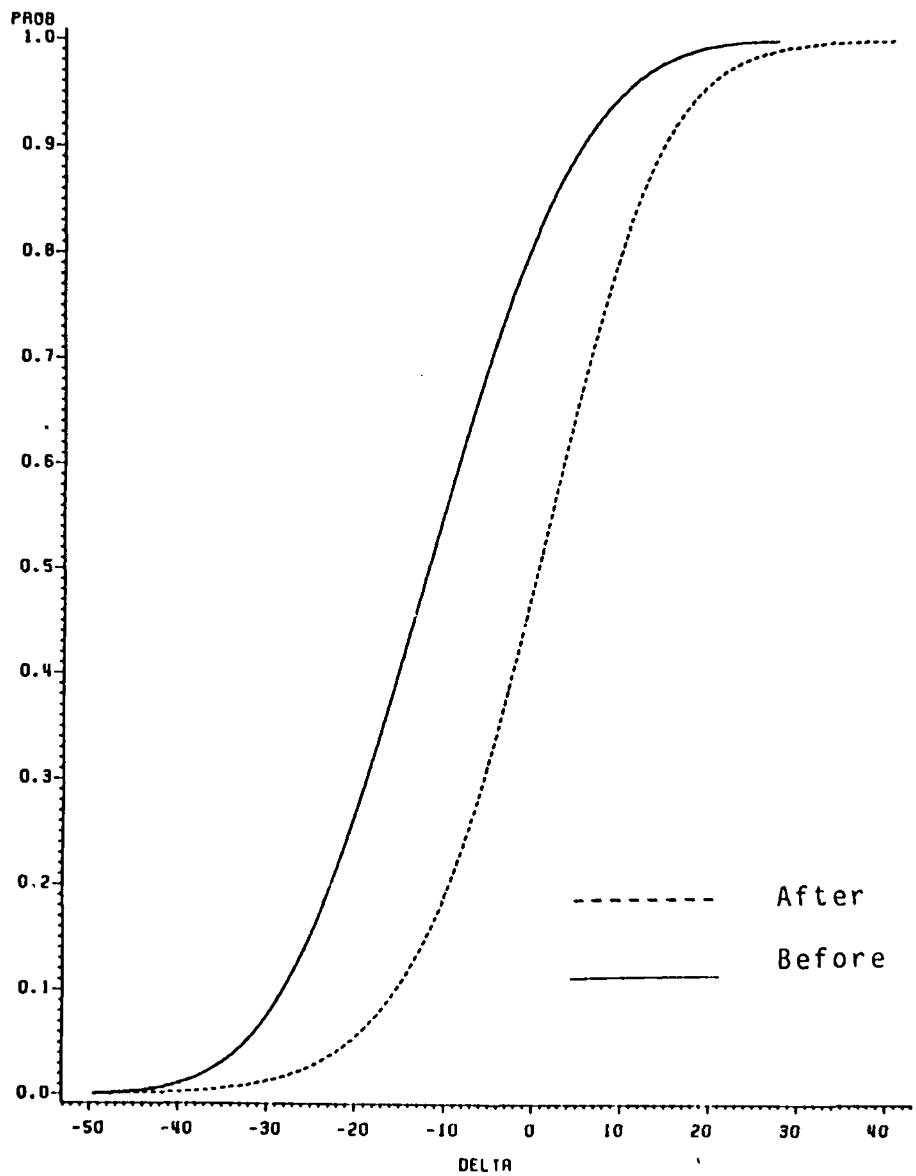


FIGURE E.2: DELTA Before and After Modeling--MRD

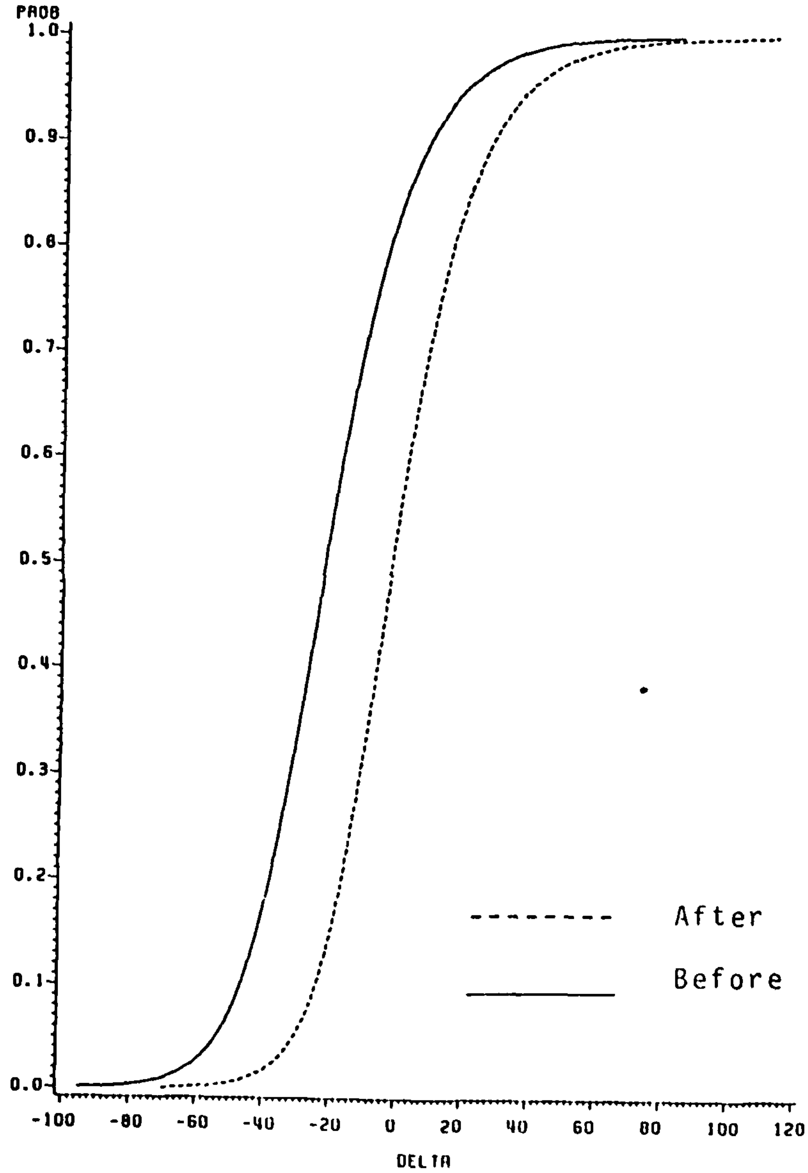


FIGURE E.3: DELTA Before and After Modeling--NAD

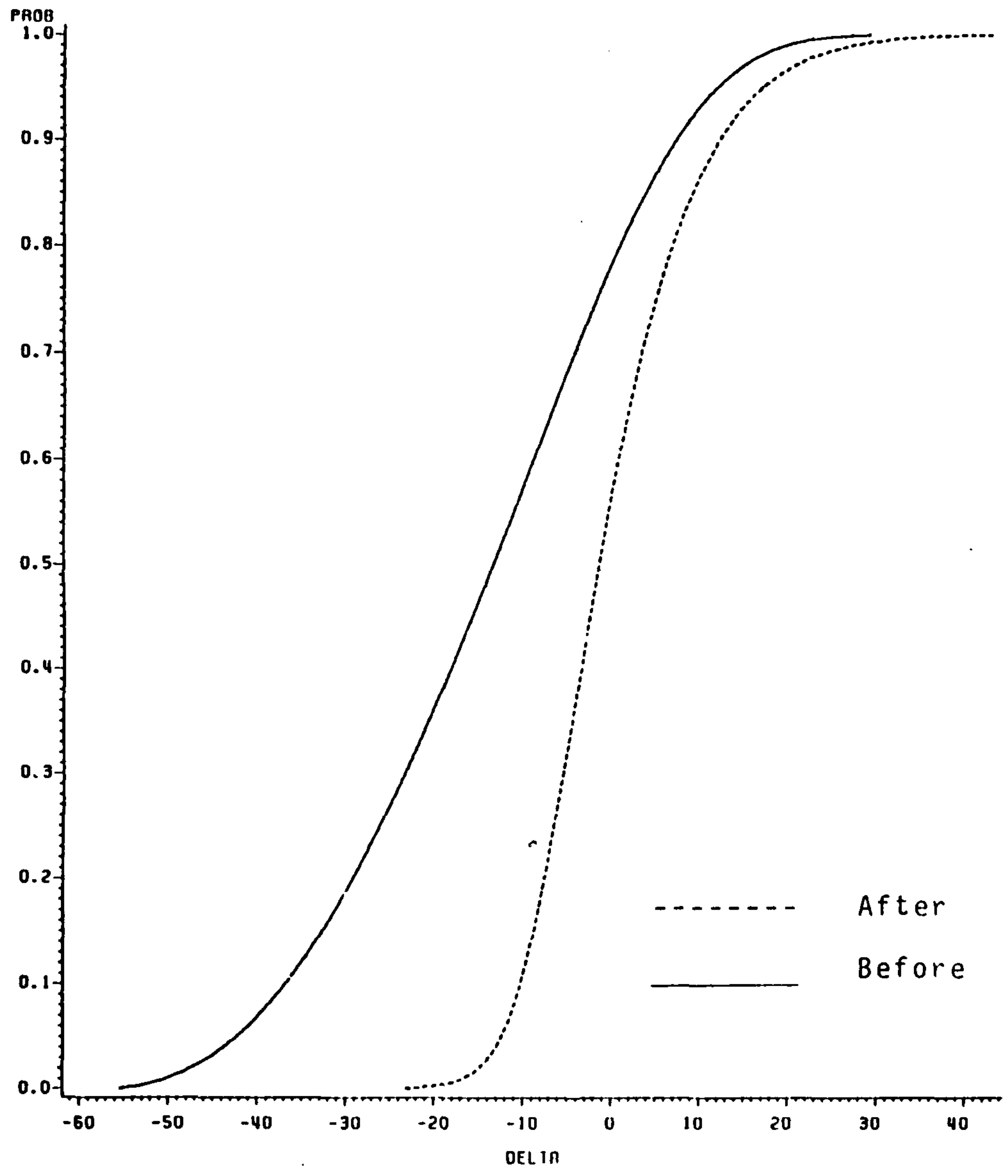


FIGURE E.4: DELTA Before and After Modeling--NPD

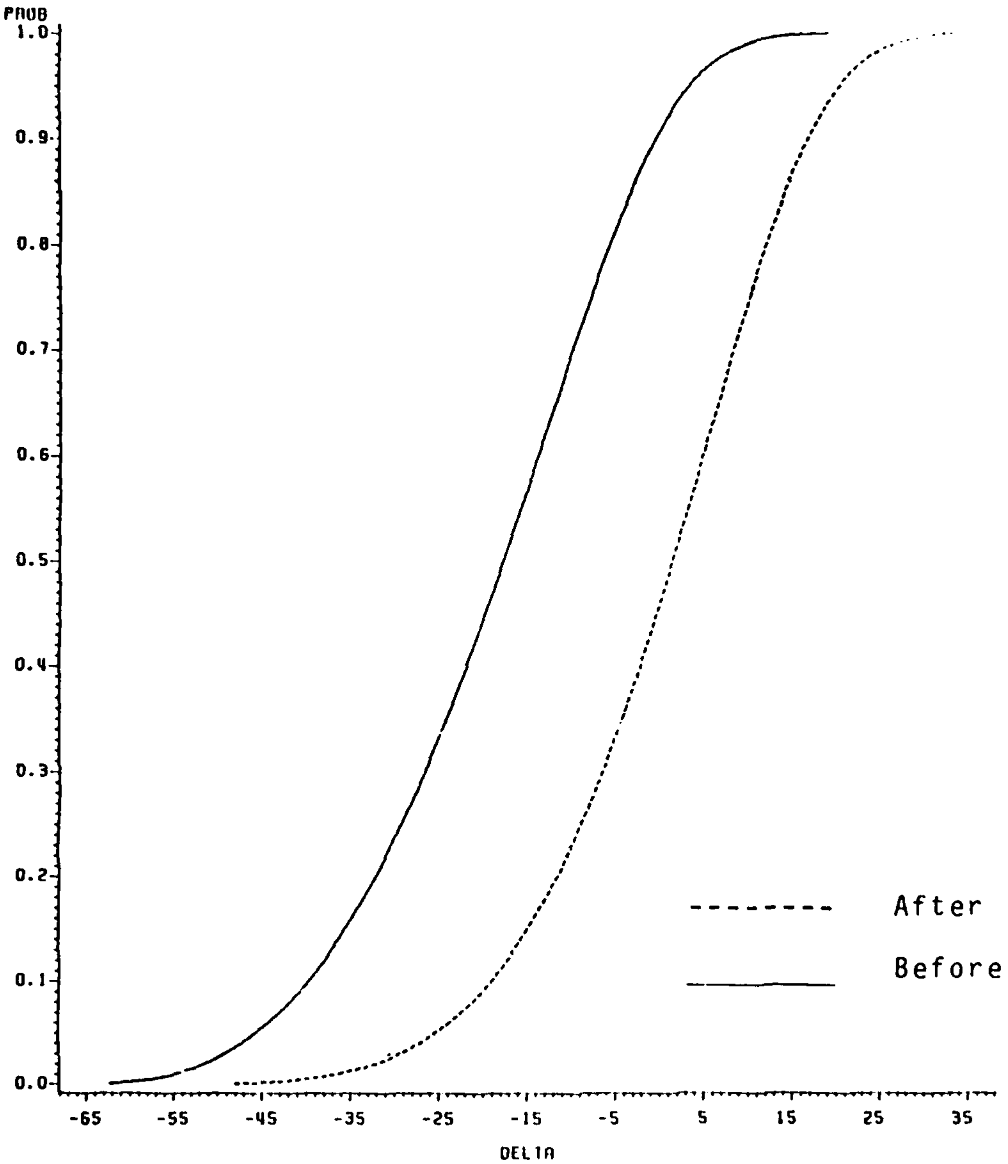


FIGURE E.5: DELTA Before and After Modeling--OHR

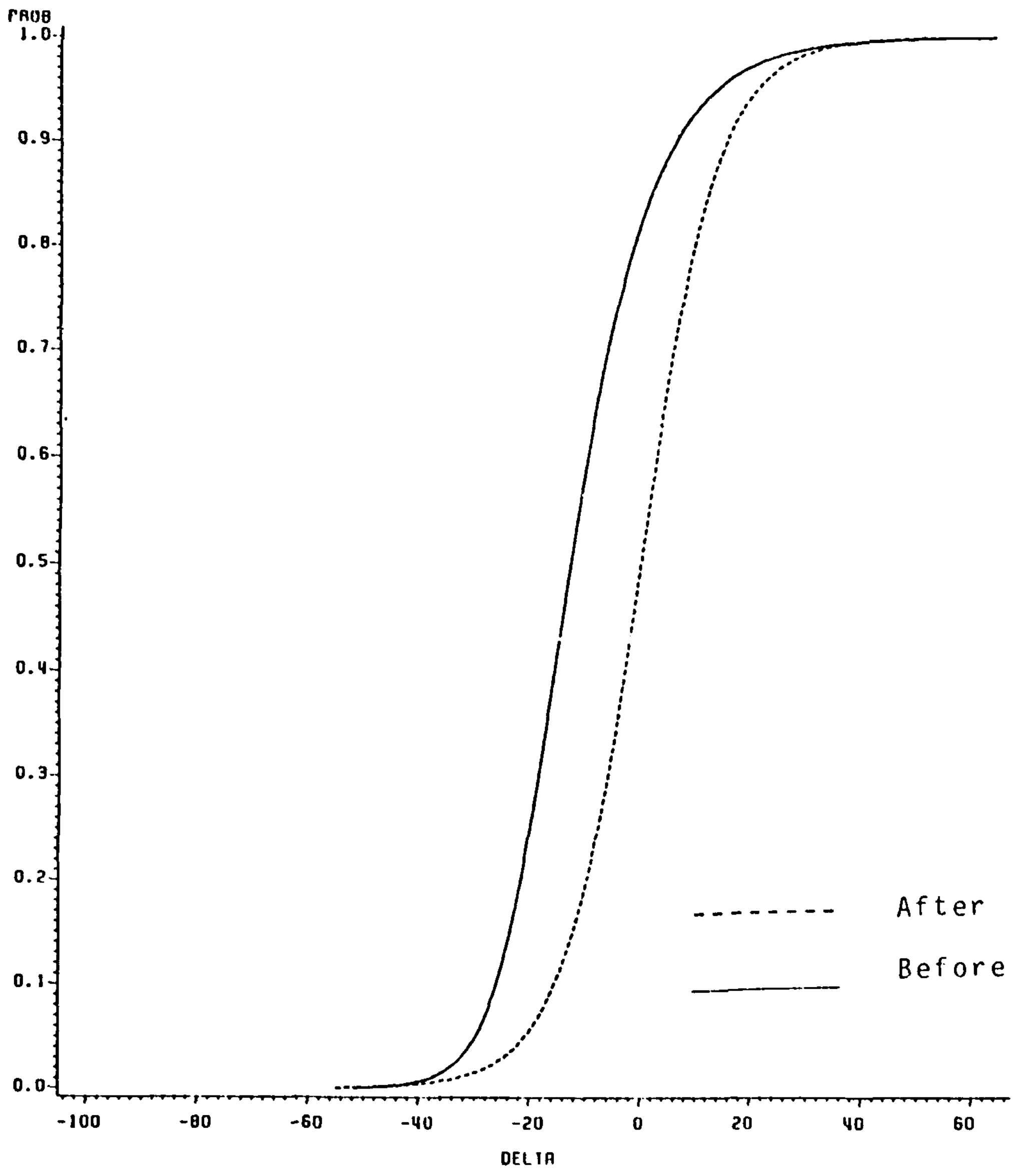


FIGURE E.6: DELTA Before and After Modeling--POD

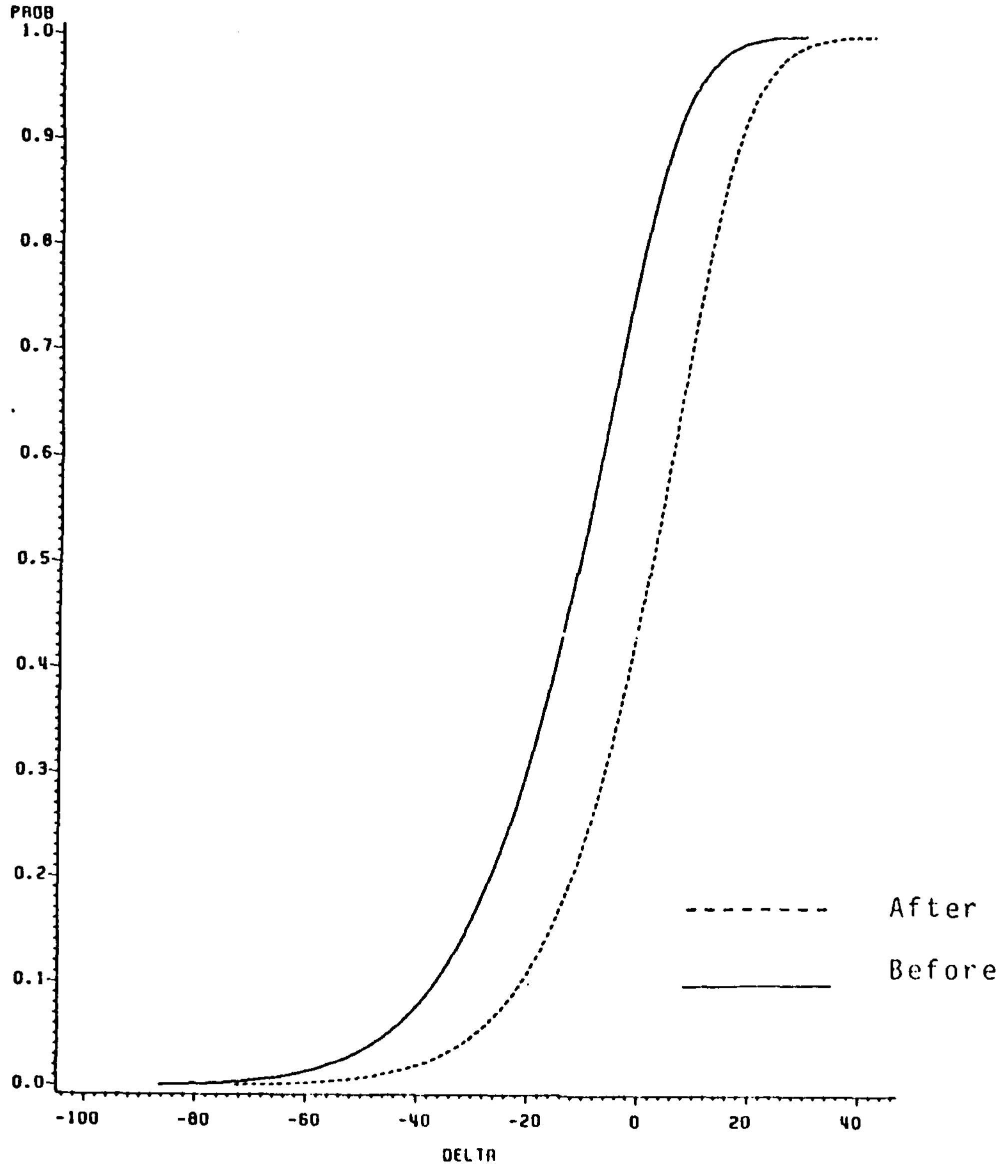


FIGURE E.7: DELTA Before and After Modeling--SAD

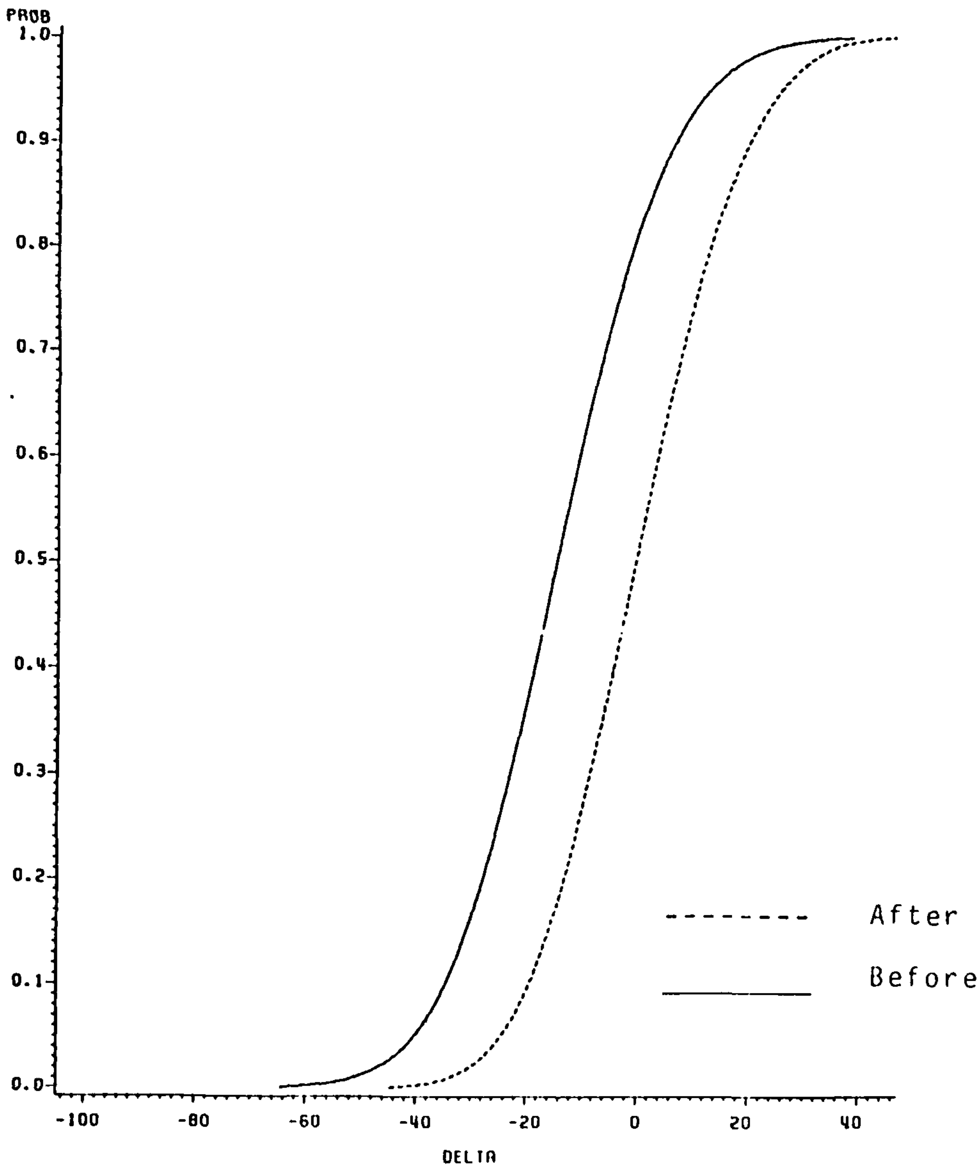


FIGURE E.8: DELTA Before and After Modeling--SPD

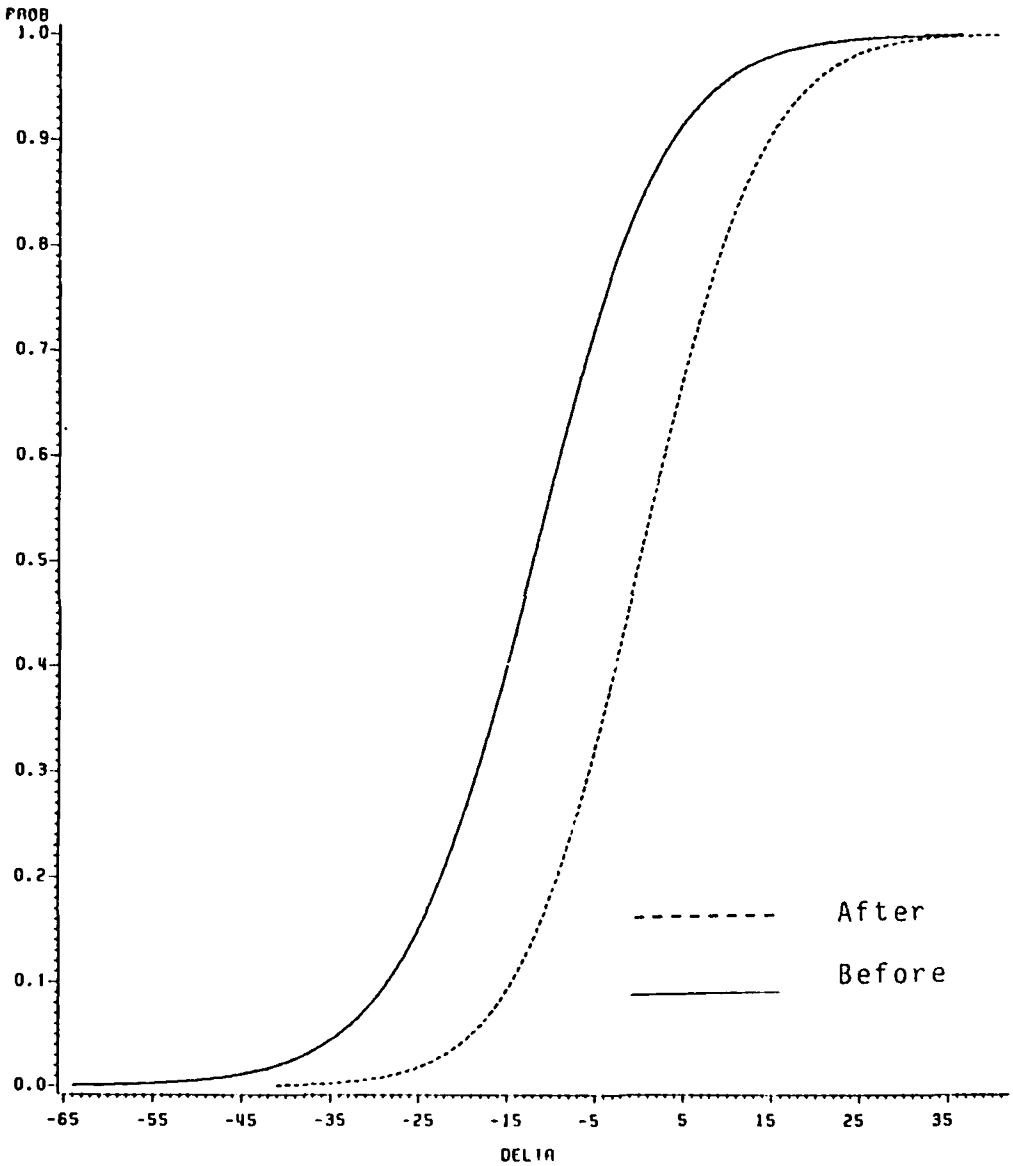


FIGURE E.9: DELTA Before and After Modeling--SWD

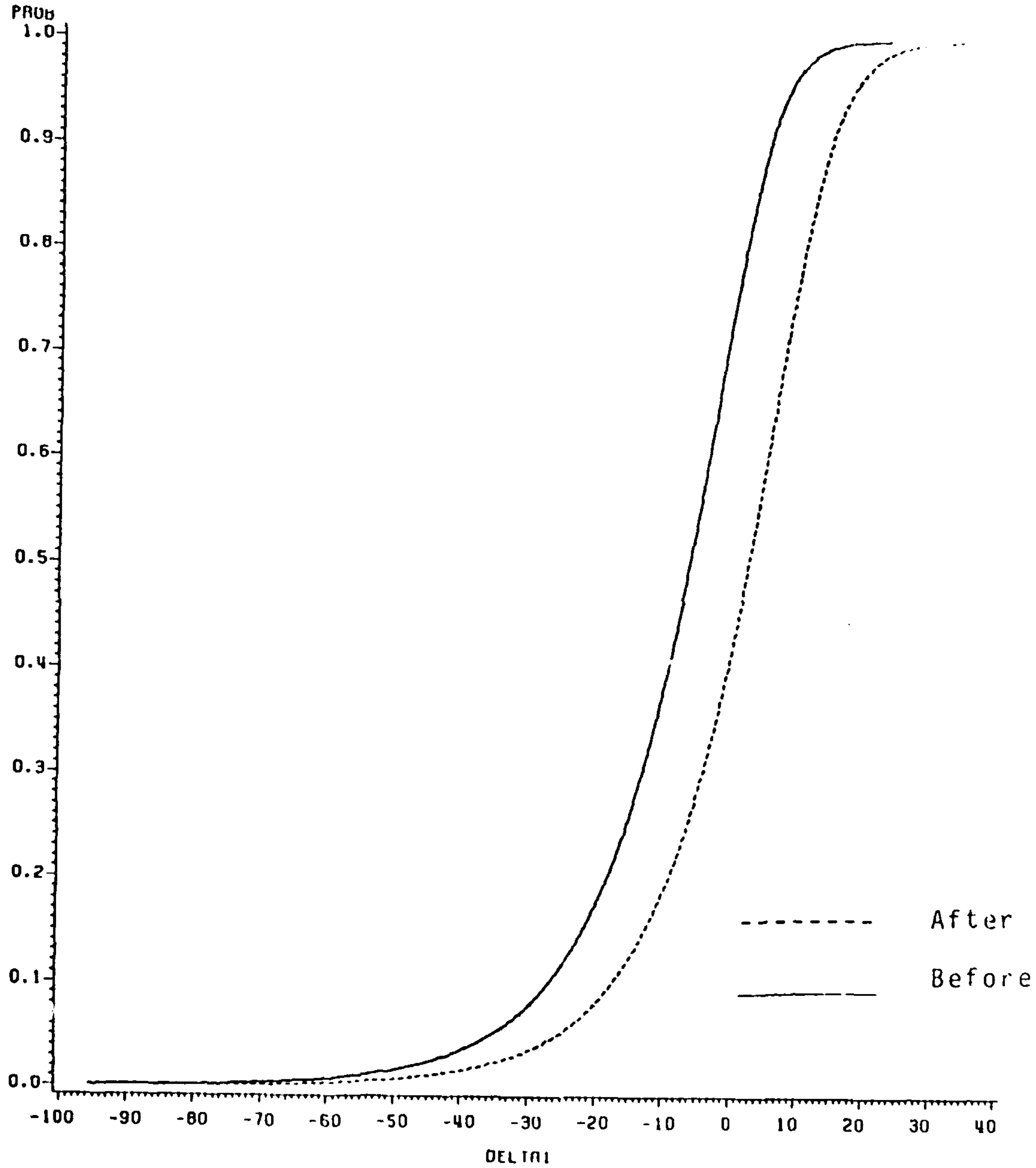


FIGURE E.10: DELTA1 Before and After Modeling--EUR

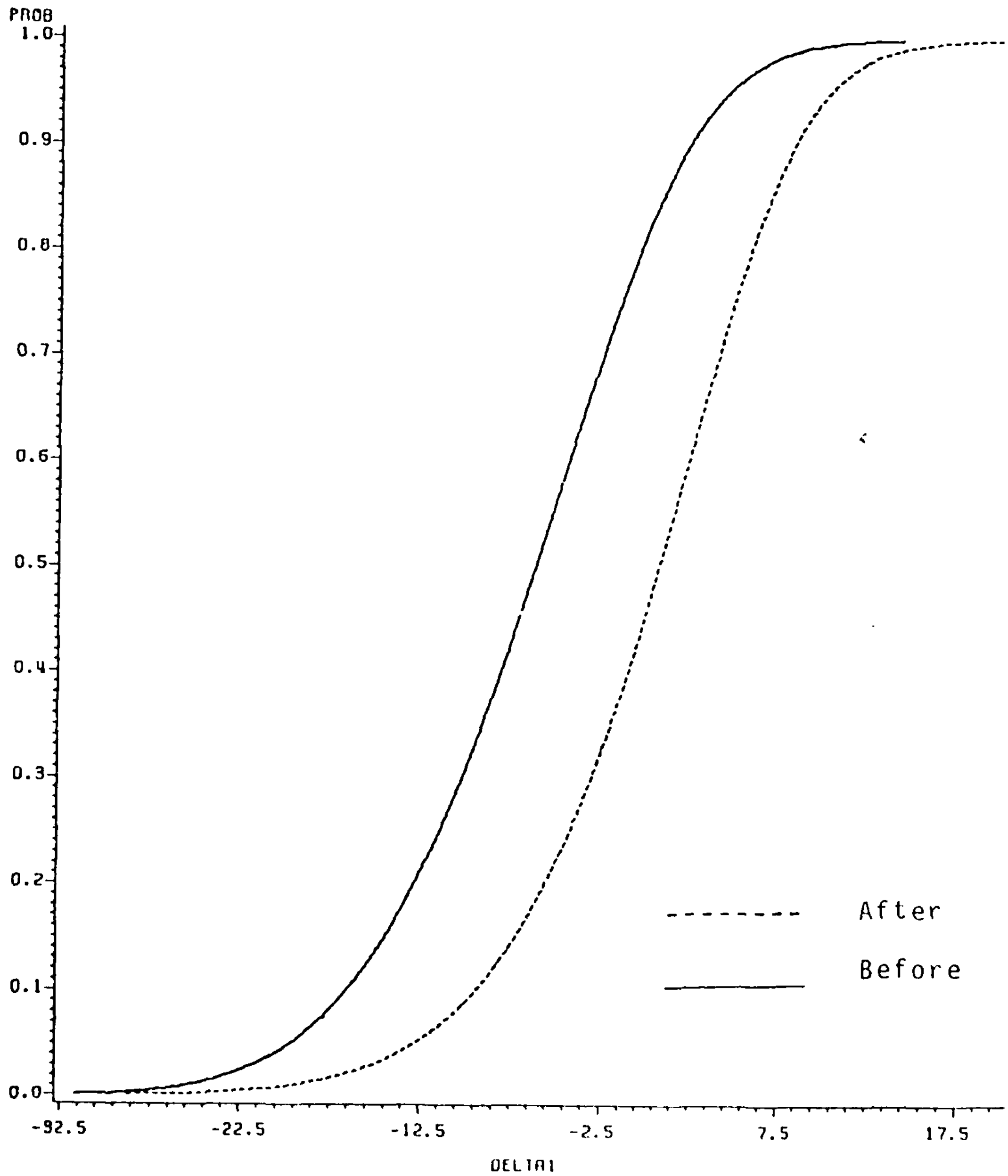


FIGURE E.11: DELTA1 Before and After Modeling--MRD

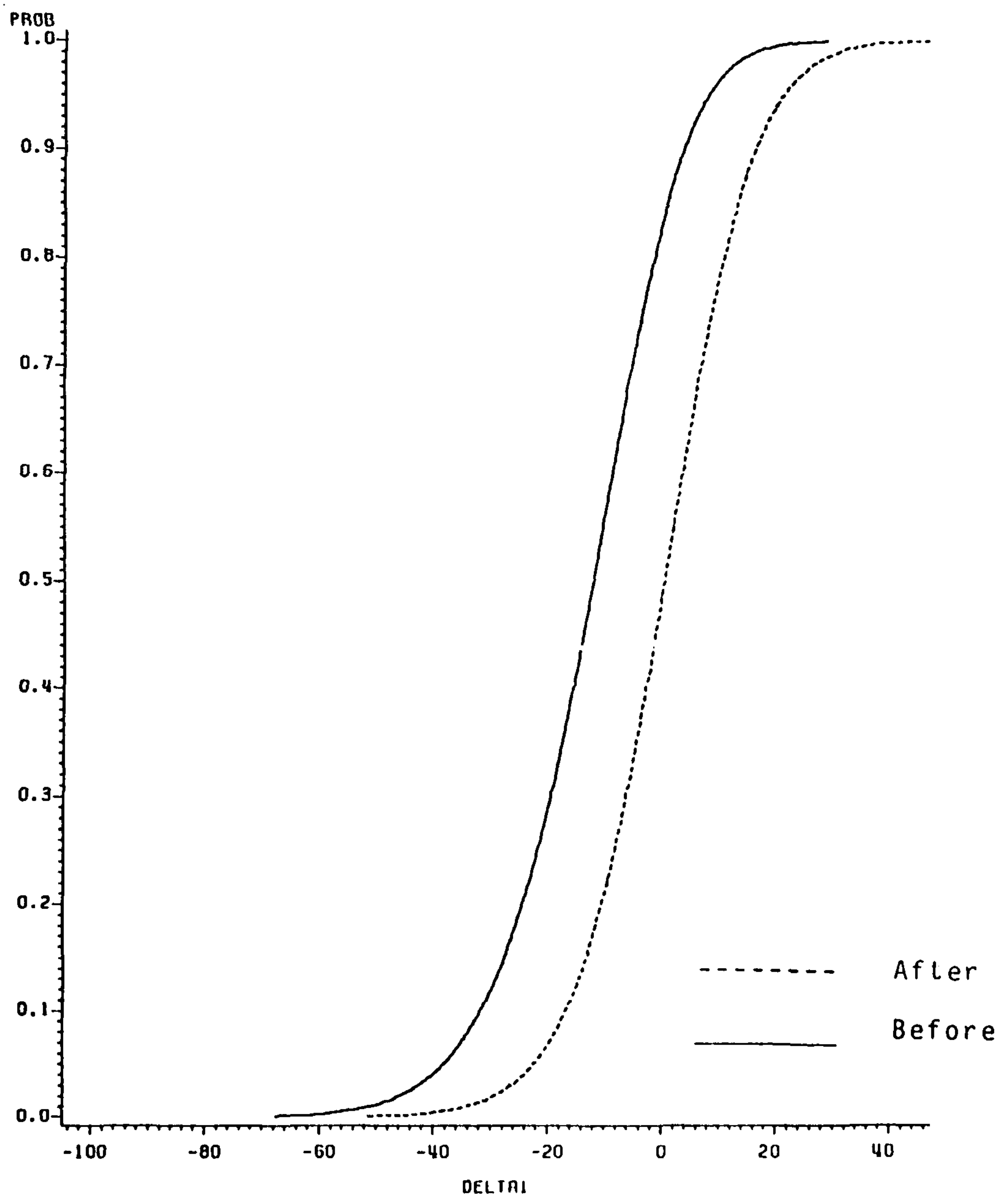


FIGURE E.12: DELTA1 Before and After Modeling--NAD

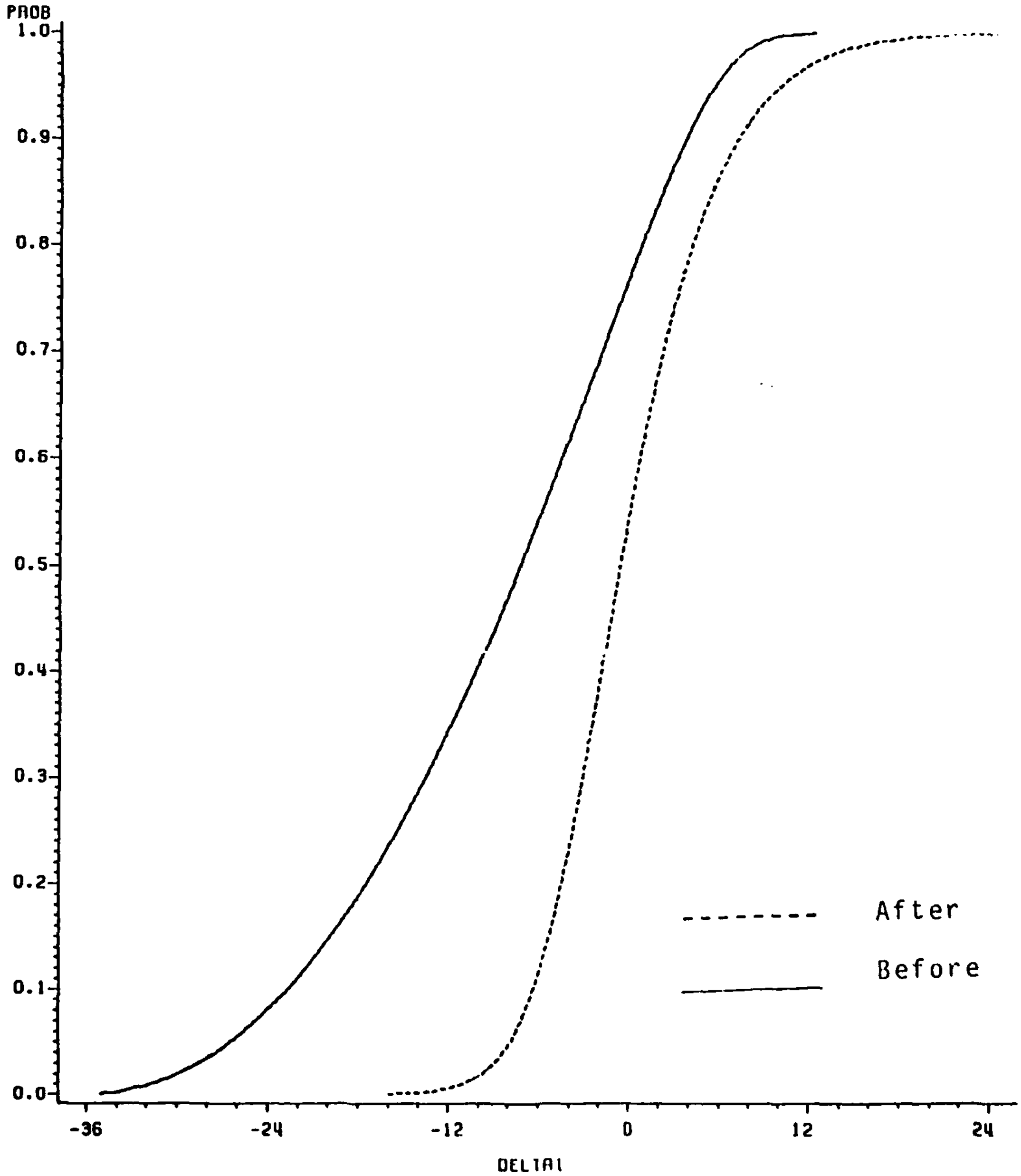


FIGURE E.13: DELTA1 Before and After Modeling--NPD

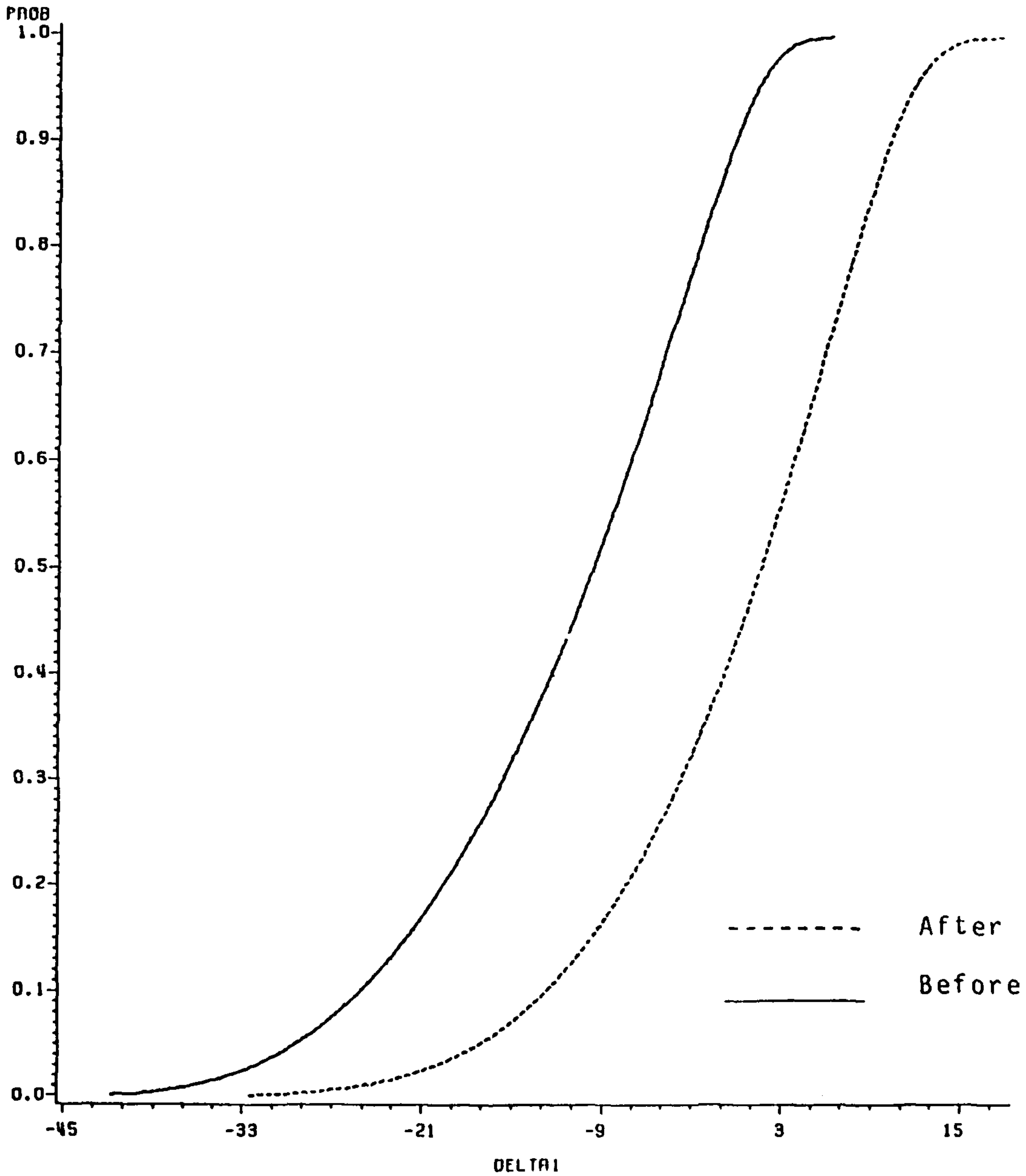


FIGURE E.14: DELTA1 Before and After Modeling--OHR

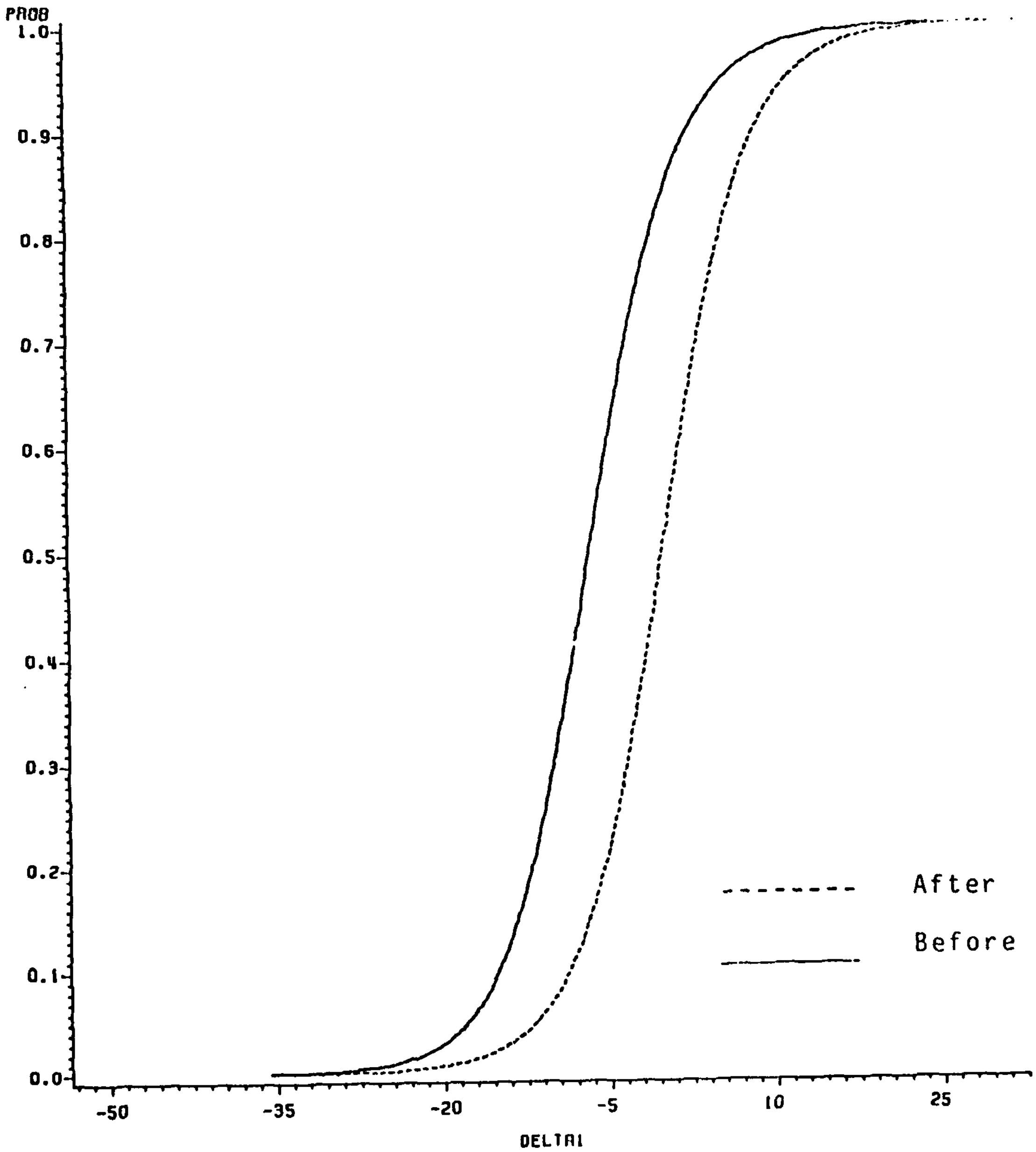


FIGURE E.15: DELTA1 Before and After Modeling--POD

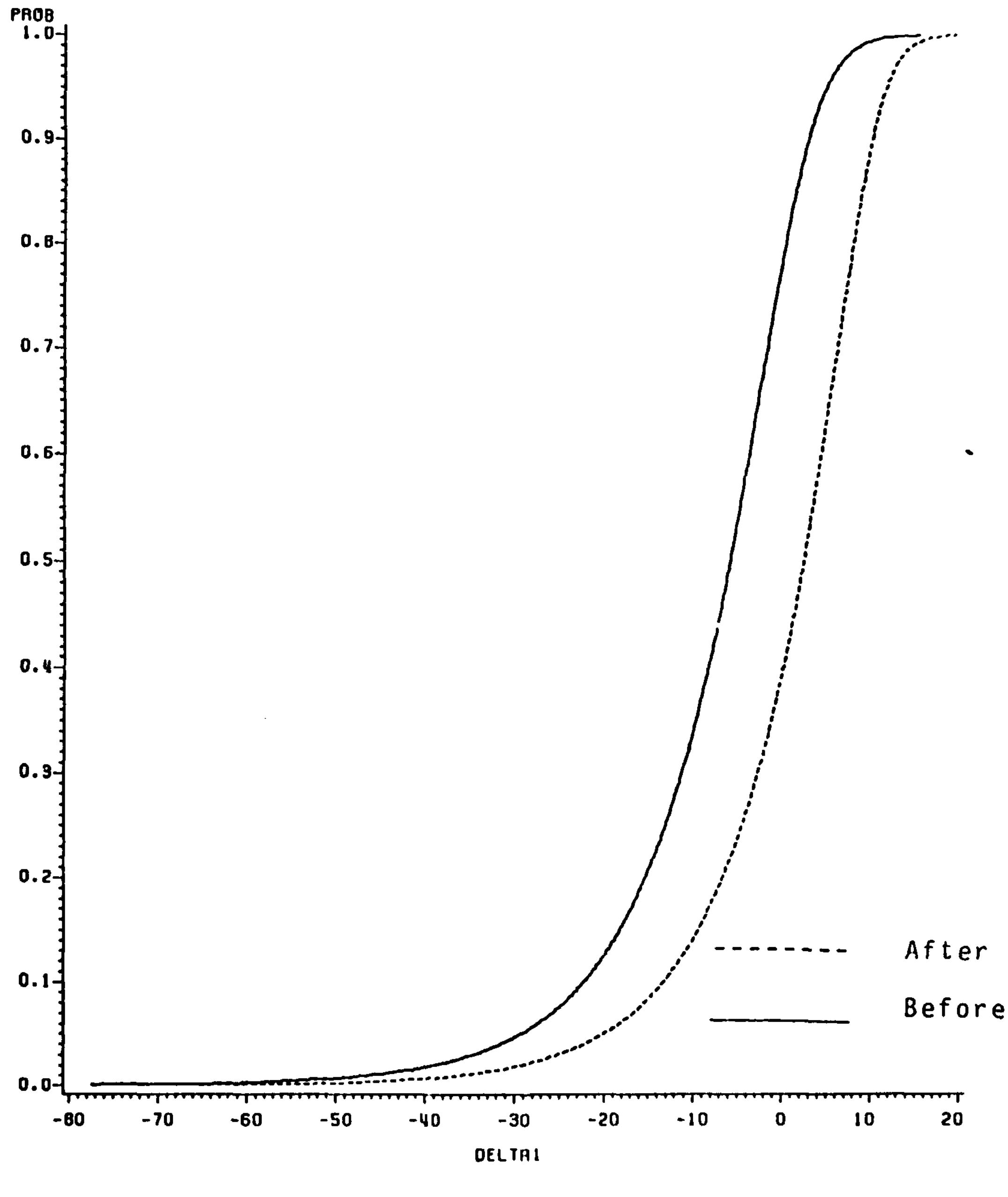


FIGURE E.16: DELTA1 Before and After Modeling--SAD

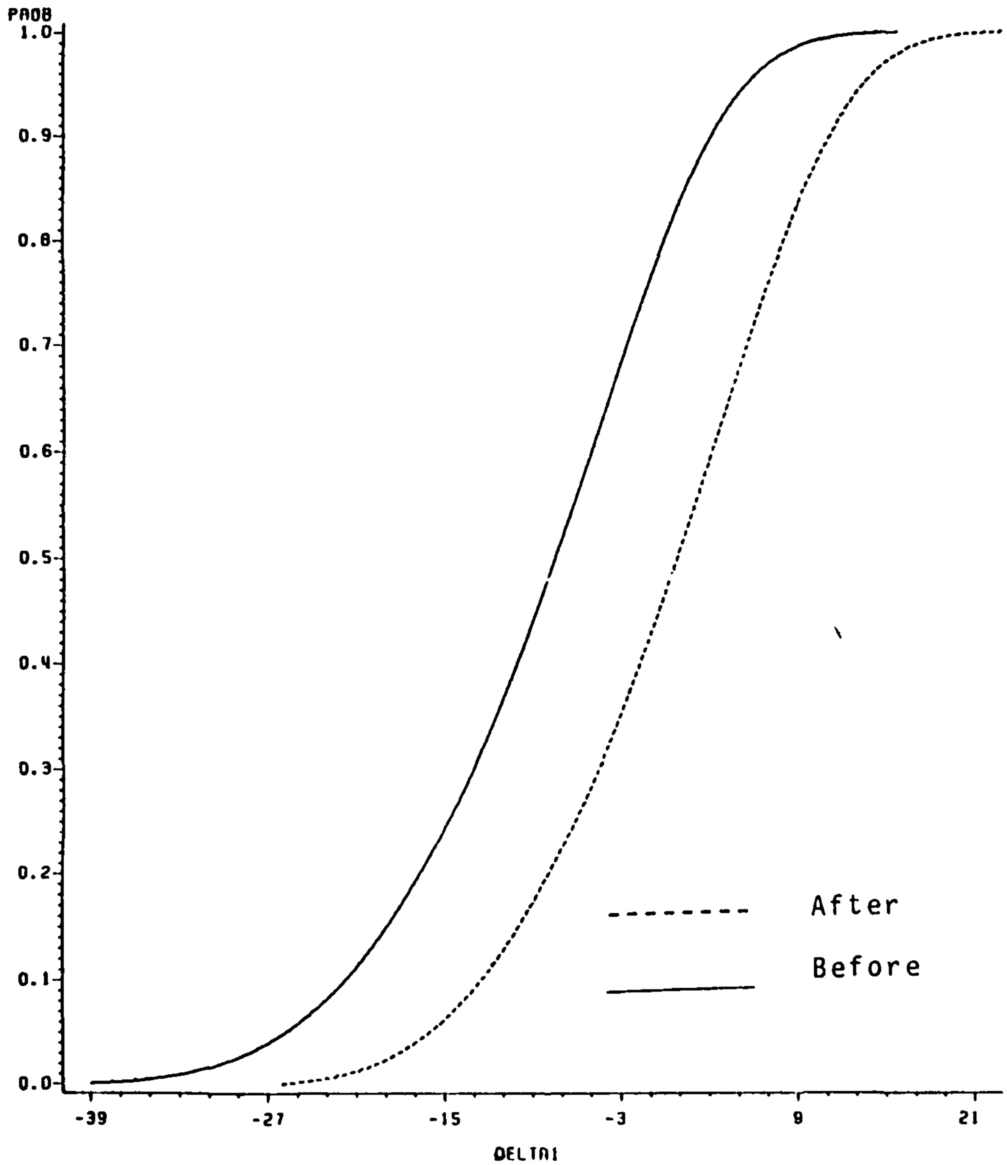


FIGURE E.17: DELTA1 Before and After Modeling--SPD

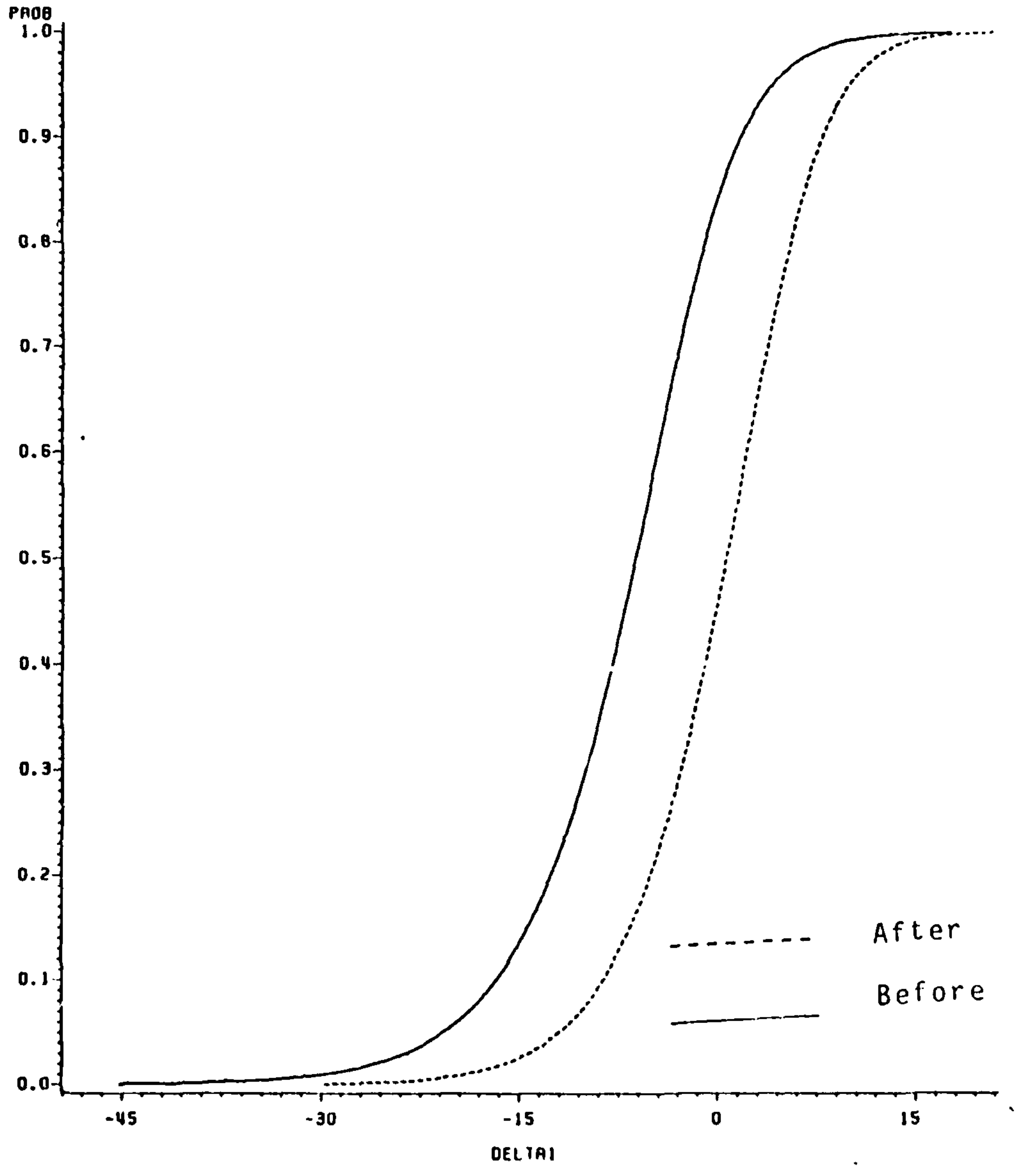


FIGURE E.18: DELTA1 Before and After Modeling--SWD

APPENDIX F

CDF OF POOLED RESIDUALS AND OVERALL MODEL

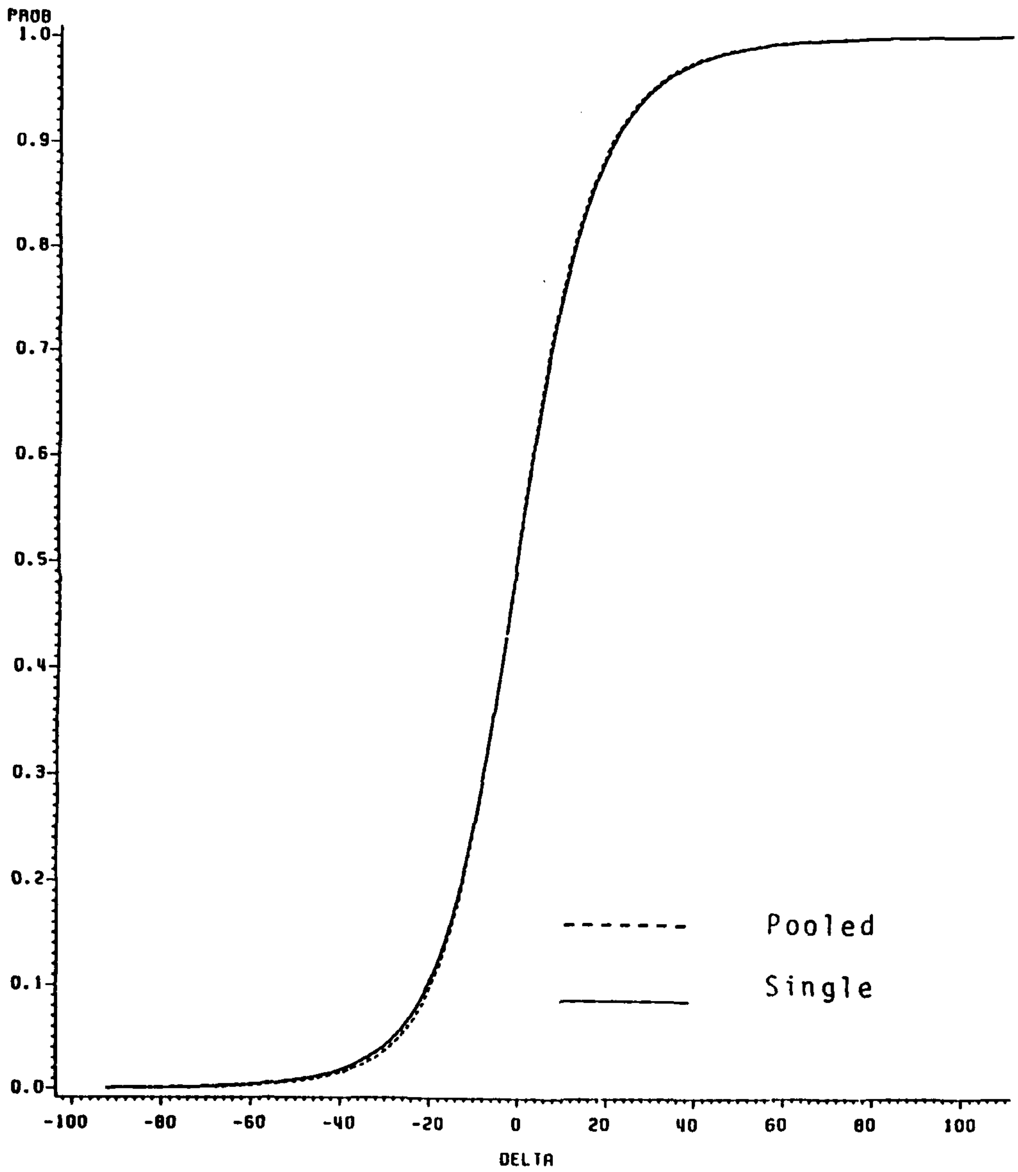


FIGURE F.1: Pooled Residuals and Overall Model--DELTA

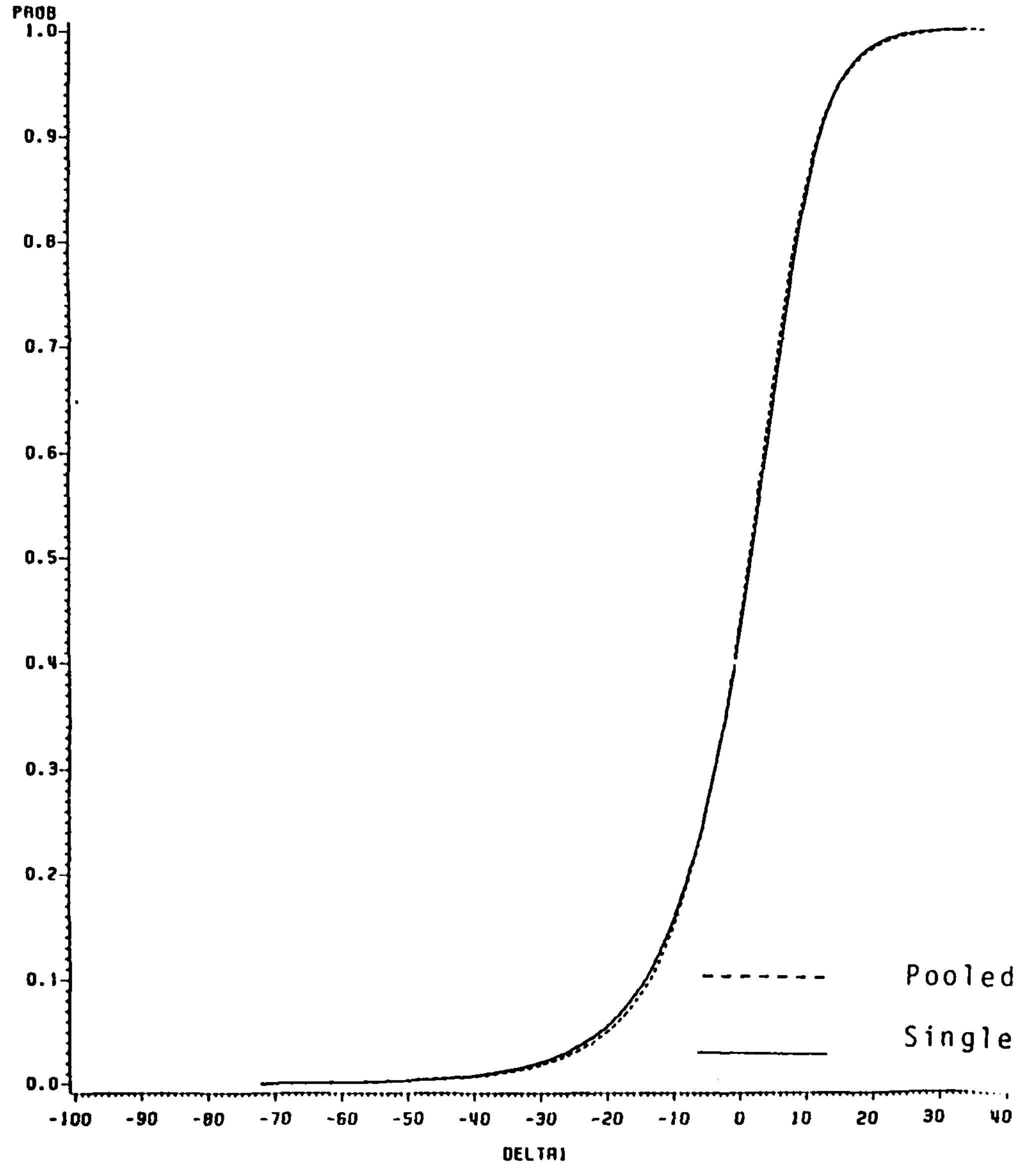


FIGURE F.2: Pooled Residuals and Overall Model--DELTA1

END

FILMED

9-85

DTIC